State of California
The Resources Agency
Department of Water Resources

SP-G2: EFFECTS OF PROJECT OPERATIONS ON GEOMORPHIC PROCESSES DOWNSTREAM OF OROVILLE DAM

Oroville Facilities Relicensing
FERC Project No. 2100

APRIL 19, 2003

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REPORT SUMMARY

The construction of Oroville Dam has altered the hydraulic, geomorphic, and sediment transport regimes of the Feather River. This study is designed to identify and evaluate ongoing effects of altered downstream hydrology and sediment retention in Lake Oroville on channel morphology and sediment transport in the Lower Feather River. Oroville. Specifically, the study will address the following components:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate stream channel stability.
5. Evaluate project-affected sediment regimes.
6. Evaluate timing, magnitude, and duration of project-affected flows in relation to geomorphic effects.
7. Determine the effect of the project on fluvial geomorphologic features.
8. Evaluate erosional effects on farmland (private and public trust resources.

Results from these tasks will be used to identify limiting factors (impacts associated with biological effects) and develop a comprehensive sediment management plan for the purposes of protection, mitigation and enhancement measures to improve form and function in the Feather River. The study results will also be used by other studies to help assess the project's ongoing effects on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

This interim progress report presents these work tasks, methodologies, and work completed to date. It presents examples of the data collected and some preliminary analyses of these data. <u>Note that data collection is ongoing and preliminary conclusions may be modified or changed by forthcoming data and analyses.</u>

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1.0 INTRODUCTION

The DWR Northern District – Geology staff is evaluating geomorphic changes to the Feather River resulting from the construction of Oroville Dam. This study concentrates on the lower Feather River below the Dam. It will be used to identify the hydraulic, geomorphic, and sediment transport changes that have occurred. The effect of these changes on salmonid spawning riffles, flooding, riparian vegetation, riparian habitat, and river habitat will be assessed. Changes in sediment transport will be evaluated for various proposed flow regimes. Based on the results of the study, we will identify needs for protection, mitigation or enhancement activities. The study results will also be used by other studies to help assess the project's ongoing effects on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

The study work plan is organized into nine discrete tasks. This interim progress report mirrors that organization by presenting methodology, interim results, and analyses for each of these tasks. It is structured using the recently received "Author's Guide to Document Preparation" (DWR, March, 2003) as a template. Because this report is an interim product, there are sections in this report where data has yet to be collected, analyzed and conclusions drawn. These gaps are noted and blank pages presented where appropriate. Note also that formatting and pagination throughout this report is not yet final. Finally a glossary of terms is not included but is available on the DWR web site at ____________________ or by requesting a copy of the current version.

1.1 BACKGROUND INFORMATION

The Feather River is an important resource for salmonid spawning habitat in California, second only to the Sacramento River. The completion of Oroville Dam in 1967 has dramatically reduced this habitat. This impact was mitigated by the Feather River Fish Hatchery. This Hatchery provides an artificial spawning and rearing facility for many salmon, although a majority still spawn naturally below the dam.

Oroville Dam also affects hydrology and sediment transport characteristics, altering the movement of water, sediment, and woody debris down the river. The primary function of the dam is to store high flows during the winter, then release them for irrigation, water supply, and power production during the summer. This results in an altered hydrologic regime that includes changes to the yearly, monthly, and daily stream flow distributions; bankfull discharge, flow exceedance, and peak flow.

It also means that the reservoir captures almost all of the sediment eroded from the watershed instead of it being distributed downriver. This changes downriver patterns of sediment transport and deposition, scour, mobilization of sediment, and levels of turbidity. All of these can result in the coarsening of spawning gravel on riffles, which in turn may adversely affect salmon and steelhead.

These changes to the river hydrology and sedimentation patterns will in turn alter the channel morphology. These can include changes to the channel shape, stability and capacity.

All of these impacts may occur downriver of Oroville Dam to it's junction with the Sacramento River or beyond. These are further complicated by a long history of a variety of land uses along the Feather River. These include hydraulic mining, gravel mining, gold dredging, timber harvesting, water diversions, and urbanization.

1.1.1 <u>Statutory/Regulatory Requirements</u>

(In Progress)

1.1.2 <u>Study Area</u>

The general study area is the ___-mile reach downriver of Oroville Dam to the confluence with the Yuba River (Figure 1). It is assumed to be the downstream extent of observable direct affects of flow modifications. It extends laterally to roughly the 500-year floodplain boundary as defined by the USACE (1997). This reach is further divided into three subreaches based on differences in the hydrologic flow regime. The first (aka the Low Flow Reach) is the seven mile stretch between the Fish Diversion Dam and the Thermalito Afterbay outflow. The second (the High Flow Reach) is the ___-mile stretch between the Afterbay outflow and Honcut Creek. The third is the ___-mile stretch between Honcut Creek and the confluence with the Yuba River. The rest of the River between Yuba City and its junction with the Sacramento River is not included in this investigation.

1.1.2.1 Description

The Feather River watershed is mainly located in the northern Sierra Nevada geomorphic province. It drains the western slope of the Sierra Nevada and is tributary to the Sacramento River. Some of the headwaters also lie within the Basin and Range geomorphic province, containing both steep forested mountains and large intermountain valleys. The climate is Mediterranean, with mostly dry summers and wet winters. Annual precipitation ranges from 75 inches in the upper watershed to 30 inches in the lower watershed near Oroville Dam.

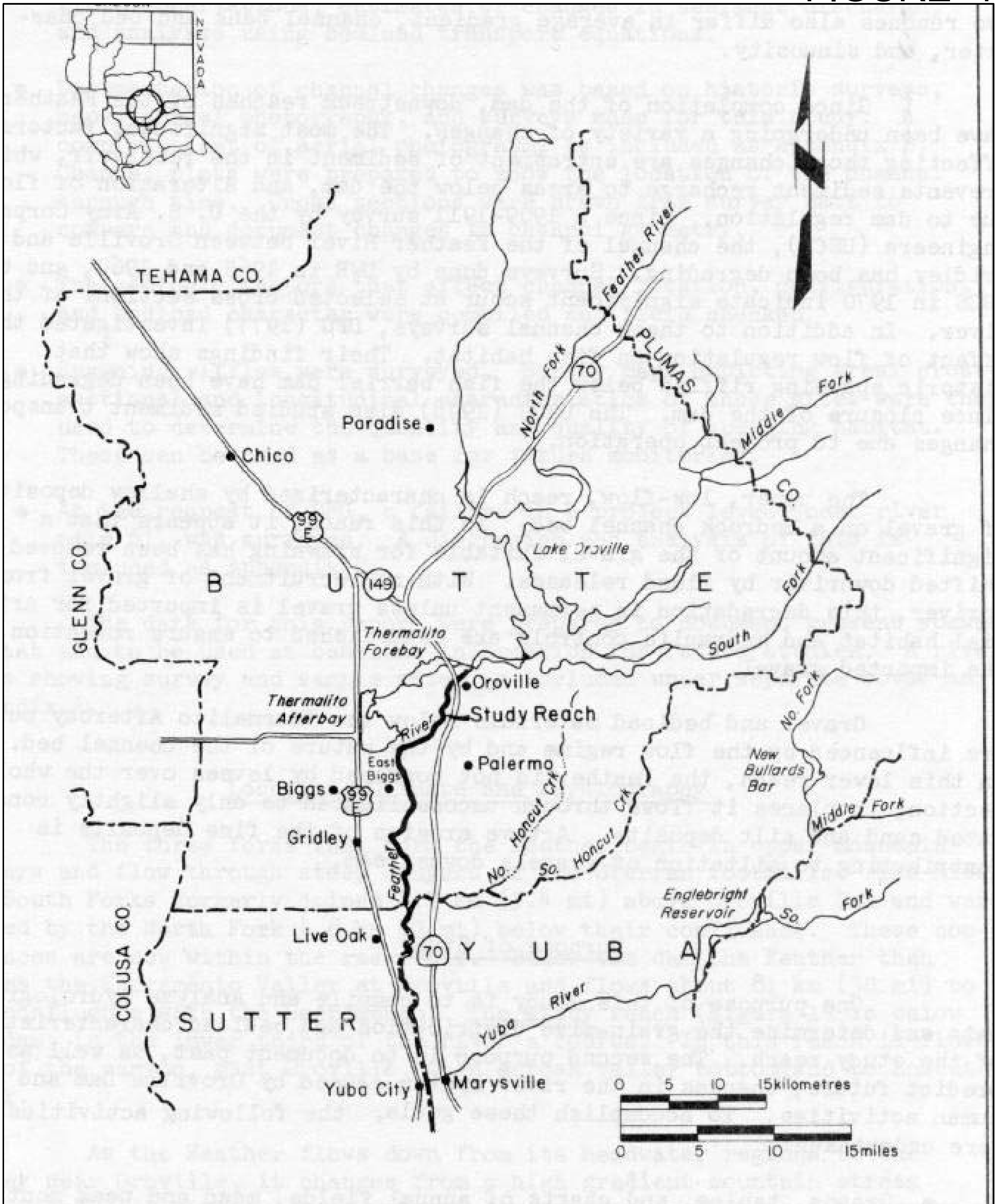
The Feather River is controlled by resistant metamorphic, volcanic, and plutonic rocks in the ___-mile reach downriver of Oroville Dam to the Diversion Dam. It is incised into these rocks, forming steep canyon walls.

The Low Flow study reach starts about half a mile downriver of the Diversion Dam, adjacent to the City of Oroville and the Oroville Wildlife Area. This is about where the Feather River emerges from the Sierra Nevada into the foothills of the Sacramento Valley. The Diversion Dam regulates the flow regime of the river, with low flows regulated from a normal flow of about 600 cfs to at least 150,000 cfs during flood events. At about three quarters of a mile below the Diversion Dam, at the first major spawning riffle, the river is still flowing in a bedrock channel. In this area the point bar, riffle gravels are relatively thin and overlay the bedrock channel. In the vicinity of Bedrock Park to the Highway 70 Bridge, the river begins to flow in an alluvial channel incised into dissected older alluvial uplands.

The High Flow Reach extends from the Afterbay outlet to Honcut Creek. The upper end of this reach is flanked by the Oroville Wildlife Area and the lower end is flanked by private orchards. This change occurs at about River Mile (RM) ___. Outflows vary during the irrigation season, reaching a maximum of about 21,000 cfs during flood events. This maximum outflow, when combined with the maximum floodflow from the Low Flow reach means that flows in the High Flow Reach can be up to 170,000 cfs.

1.1.2.1.1 River Access

Many locations are accessible by vehicle through the Oroville Wildlife Area. Numerous public boat ramps are also available. Access to the Low Flow Reach supported by a public ramp on the left bank at River Run Park, a private ramp on the left bank at the _____ Trailer Park, and a public ramp on the right bank just upriver of the Thermalito Afterbay outflow. Access to the High Flow Reach is also supported by the Afterbay ramp, a private ramp on the left bank downriver of the Gridley Bridge, and a public boat ramp on the right bank just east of the town of Live Oak. Jet boats can often be used in the High Flow Reach and sometimes in the Low Flow Reach dependent on flow. Seasonal variations in flow can often make some riffles difficult or impossible to navigate and submerged snags can be an additional hazard.



FEATHER RIVER GEOMORPHIC STUDY AREA
LAKE OROVILLE TO YUBA CITY

1.1.2.2 History

(In Progress)

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the

114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 8,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

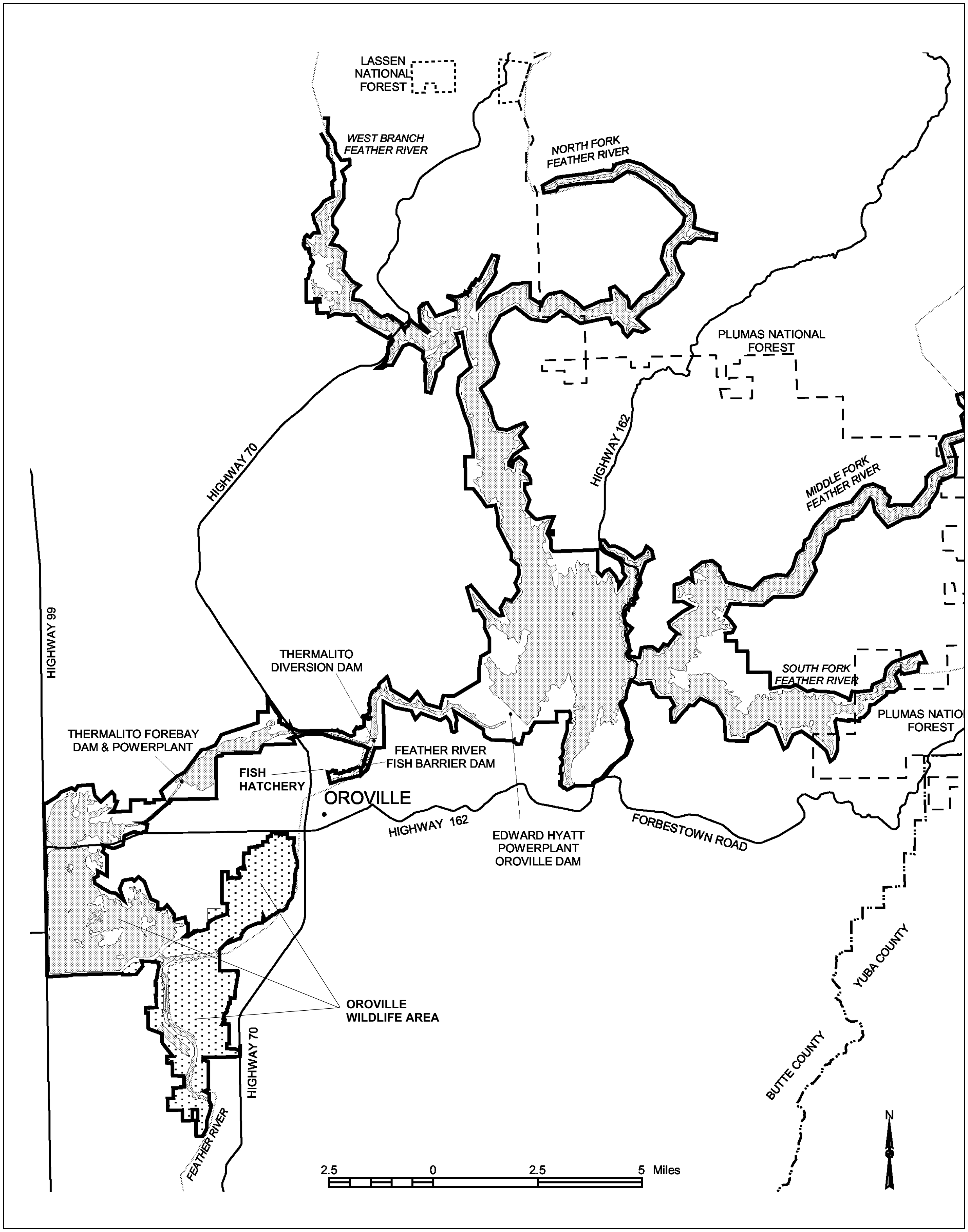


Figure 2. Oroville Facilities FERC Project Boundary

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning are conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake

Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

2.1 PURPOSE AND SCOPE

A naturally functioning channel in dynamic equilibrium is capable of transporting the water and sediment delivered to it without significantly changing its geometry, streambed composition, or gradient through time. The flow conditions that promote this stability can be described as geomorphically significant flows (bankfull). These flows do the majority of the sediment transport and are considered most responsible for channel form. A natural flow regime typically includes flow ranges responsible for in-channel clearing and overbank flows to support riparian vegetation, along with channel-forming flows.

The altered sediment routing and hydrology caused by the Oroville Facilities have affected river morphology. There is a need to understand these relationships and identify potential protection, mitigation and enhancement measures.

The geomorphic investigation will compare historic and current conditions to help identify ongoing project effects to the downstream reach defined in this study. This information will be used to identify continuing project effects to downstream geomorphologic processes. It will also be used by other studies to help assess the project's effects on plant, fish, animal, and riparian resources caused by hydrologic, channel, and sediment routing changes. These data, together with other study results, will provide boundary conditions for assessing potential management actions.

Project -related structures and operations also alter flow regimes, which can impact the occurrence of geomorphically significant flows. Potential adverse effects include loss of undercut banks, increased instream fine sediment, braiding, loss of channel capacity, reduced sediment transport capability, gravel displacement, unnatural channel scour, armoring, and impairment of the ability of the stream to maintain functional riparian and instream habitat. Project-related structures and operations can also impair the stream's ability to transport the sediment delivered to it from source areas.

3.0 STUDY OBJECTIVE(S)

3.1 APPLICATION OF STUDY INFORMATION

The objective is to determine the ongoing effects of altered downstream hydrology and sediment retention in Lake Oroville on channel morphology and sediment transport below Lake Oroville. Study results will be used to identify limiting factors (impacts associated with biological effects) and develop a comprehensive sediment management plan for the purposes of protection, mitigation and enhancement measures to improve form and function in the Feather River. The study results will also be used by other studies to help assess the project's ongoing effects on downstream water quality, aquatic and riparian resources, and protection of private lands and public trust resources.

This study will determine the ongoing effect of flows on the morphology of project affected streams and project impoundments downstream of Oroville Dam. Specifically, the study will address the following components:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate stream channel stability.
5. Evaluate project-affected sediment regimes.
6. Evaluate timing, magnitude, and duration of project-affected flows in relation to geomorphic effects.
7. Determine the effect of the project on fluvial geomorphologic features.
8. Evaluate erosional effects on farmland (private and public trust resources.

3.1.1 Department of Water Resources/Stakeholders

(In Progress)

3.1.2 Other Studies

Studies related to spawning gravel quantity and quality began before construction of Oroville Dam. DWR (1965) studied pre-dam channel characteristics, and then DWR (1969) and the USGS (1972) conducted studies to document channel changes. In 1977 DF&G studied the interim impacts of the dam on salmonid escapement. In 1978 the USGS did another study to evaluate sediment transport and discharge. Because of the findings of several of the previous investigations, DWR (1982) prepared the Feather River Spawning Gravel Baseline Study to determine the condition of spawning gravel in the upper Feather River. The report identified factors resulting in the reduction of spawning gravel quality. These include the loss of gravel recruitment from areas above Oroville Dam and the effect of scouring flood flows. A follow-up habitat restoration project was conducted by DWR and DF&G in 1982 at the riffle sites adjacent to the Hatchery. These sites were identified in the baseline study as having undergone significant post-dam degradation.

Surface and bulk gravel sampling for the 1982 study showed that riffles in the river between the Oroville Fish Hatchery and the Highway 70 Bridge are paved by cobbles. The degree of armoring diminishes downstream. Below the Highway 162 Bridge the armoring effect diminishes rapidly and the gravel in riffles is generally appropriate for salmon spawning.

In the 1982 study, surface samples were taken on point bars and the size distribution, median, first and second standard deviation, skewness and kurtosis calculated. One hundred and seventy six surface samples were taken between the Fish Barrier Dam and Honcut Creek. Bulk samples were taken on 18 point bars.

Although the study concluded that in-channel enhancement projects would run a high risk of failure because of high velocities, lack of recruitment, and short flood recurrence intervals, it also proposed a comprehensive management and monitoring program that included restoration and enhancement of habit.

3.1.3 Engineering Exhibits

(In Progress)

3.1.4 Environmental Documentation

(In Progress)

3.1.5 Settlement Agreement

(In Progress)

4.0 STUDY ORGANIZATION

4.1 STUDY DESIGN

The study is organized into nine individual tasks. These tasks are to:

- obtain, review, and summarize existing resource data;
- map and characterize spawning riffles;
- evaluate changes to the channel morphology by re-establishing historic cross-section surveys;
- assess current channel characteristics and monitor selected cross-sections for significant changes to those characteristics;
- determine project effects on river geomorphic and hydraulic parameters;
- establish bank erosion monitoring sites;
- model sediment transport and channel hydraulics;
- submit a draft report;
- and to prepare a final report.

4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

DWR Northern District – Geology staff has worked on SP-G2 for the last year. Office work has focused on researching and collecting references and data sets, performing sieve analyses of sediment samples, documenting field surveys, and preparation of maps, charts, and figures. The work has been geared to providing data for development of the Fluvial-12 sediment transport model. This ongoing work includes weekly coordination with DWR - Engineering and Dr. Chang, the model developer and consultant. Field work has concentrated on finding and re-surveying historic cross-sections, collecting bulk and sediment samples, and river habitat classification. Most of the work has been done in the Low and High Flow Reaches. The emphasis has been on the Low Flow Reach because this is the initial calibration reach for the Fluvial-12 sediment transport model. Additional details of sampling locations and methodologies are provided later in this report.

5.0 STUDY RESOURCES AND PHYSIOGRAPHIC SETTING

DWR has compiled previous work using the State Resources Agency Library and extensive in-house publications. Hydrologic and cross-section data have been compiled and a set of base maps obtained for plotting the data. This base map is an integration of the DWR 1982 aerial photo atlas with the 1997 USACE topographic map ping. This is being used as a base to compile additional historic river meanders, historic surveys, and current field surveying and sampling. It will be used as a resource for charting changes in stream morphology, vegetation, land use, and other data. It will also be coordinated with the DWR Geographic Information System (GIS).

5.1 METHODOLOGY AND RESULTS

5.1.1 Study Resources

"Review of previous work will include compiling data sets, assessing the adequacy of the data, and identifying data gaps."

(In Progress)

5.1.1.1 References

"DWR will compile previous work using the State Resources Agency Library and extensive in-house publications"

Geology staff catalogued existing references in the Northern District offices. The State Library was queried and a list of about ____ references generated. Those references not available at Northern District were requested from the State Library. Many of these have been received and copied, however several remain outstanding that are only available through inter-library loan. These continue to be received. Available publications are listed under the section 12.2 Bibliography at the end of this report.

5.1.1.2 Aerial Photography

"Available photography will be compiled. The historical photography is a valuable resource for charting changes in stream morphology, vegetation, land use, and other data. The most recent photography will be ortho-corrected and used as a base for a Geographic Information System (GIS). "

The 1982, 1990, 1997 and 2001 aerial photography of the Low and High Flow reaches has been rectified and compiled into a working AutoCad base file. Additional historic aerial photography for 1945, 1955, and 1956 has been scanned and indexed into this base. Numerous other data sets are available. Some of these are listed in Table 1.

(In Progress)

Table 1. Index of Historical Aerial Photography for the Lower Feather River

5.1.1.3 Maps

"A set of base maps will be obtained for plotting the data. A set of these maps is in the DWR map library. The maps show the low flow reach in great detail. An aerial photo atlas published by DWR also shows spawning riffle and cross-section locations. These will be useful for quantifying historic changes to the river channel that will be used to help quantify ongoing project effects."

(In Progress)

Table 2. Index of Available Maps

5.1.1.4 Survey Data

"Cross-section data will be compiled."

(In Progress)

Table 3. Index of Historical Cross-sections

Date of Survey	Agency	Author	Report Reference Number*	Report Date	Riffle/ Feature/ Cross Section	1997 USACE RM	Cross-section Code	Purpose	Comments
					Fish Diversion Dam	66.54			Start of DWR 1981 Study
1972	USGS	Blodgett	20	1972	cross-section	66.53	68		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	66.51	67.1		(these RM's are USGS footage adjusted to DWR RM's)
					Table Mountain Blvd.	66.29			
1972	USGS	Blodgett	20	1972	cross-section	66.27	67		(these RM's are USGS footage adjusted to DWR RM's)
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.10	A	spawning channel changes	at Hatchery Riffle; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.08	B	spawning channel changes	at Hatchery Riffle; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.07	C	spawning channel changes	u/s end of Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.07	C	spawning channel changes	u/s end of Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.07	C	spawning channel changes	u/s end of Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.05	D	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.05	D	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.05	D	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.03	E	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.03	E	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.03	E	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Jul-81	DWR - ND	Buer, Eaves	110	1982	Hatchery Riffle	66.02			
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.00	F	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.00	F	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	66.00	F	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.98	G	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.98	G	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.98	G	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.96	H	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.96	H	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.96	H	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.94	I	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.94	I	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.94	I	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.93	J	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.93	J	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.93	J	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	65.92	HATCHERY 1		
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.90	K	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.90	K	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.90	K	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
1972	USGS	Blodgett	20	1972	cross-section	65.89	66		(these RM's are USGS footage adjusted to DWR RM's)
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.87	L	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.87	L	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.87	L	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.85	M	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.85	M	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.85	M	spawning channel changes	at Moe's Ditch; survey only water edge to water edge
Jul-81	DWR - ND	Buer, Eaves	110	1982	Moe's Ditch	65.84			
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.83	N	spawning channel changes	d/s end of Moe's Ditch; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.83	N	spawning channel changes	d/s end of Moe's Ditch; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.83	N	spawning channel changes	d/s end of Moe's Ditch; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.81	O	spawning channel changes	at Auditorium Riffle; survey only water edge to water edge
Sep-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.81	O	spawning channel changes	at Auditorium Riffle; survey only water edge to water edge
Apr-83	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.81	O	spawning channel changes	at Auditorium Riffle; survey only water edge to water edge
Aug-82	DWR - ND	Buer, Eaves	135	Jul-83	cross-section	65.78	P	spawning channel changes	at Auditorium Riffle; survey only water edge to water edge
Jul-81	DWR - ND	Buer, Eaves	110	1982	Auditorium Riffle	65.74			
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	65.72	AUDITORIUM 3	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	65.72	AUDITORIUM 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	65.72	AUDITORIUM 1	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	65.51	65		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Bedrock Park Riffle	65.13			
1972	USGS	Blodgett	20	1972	cross-section	65.12	64		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	65.03	63.1		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	65.00	B - B'	resurvey of USGS x/s	
					Highway 70 Bridge	65.00			
1972	USGS	Blodgett	20	1972	cross-section	64.99	63		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	64.95	62		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	64.65	61		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	64.63	C - C'	resurvey of USGS x/s	just downstream of USGS location
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	64.36	HWY 162 Bridge	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	64.30	60		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	64.24	D - D'	resurvey of USGS x/s	
1972	USGS	Blodgett	20	1972	cross-section	64.02	59		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.99	E - E'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.86	F - F'	resurvey of USGS x/s	
					Highway 162 Bridge	63.86			
1972	USGS	Blodgett	20	1972	cross-section	63.85	58		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.78	G - G'	resurvey of USGS x/s	
1972	USGS	Blodgett	20	1972	cross-section	63.78	57		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.61	H - H'	resurvey of USGS x/s	
1972	USGS	Blodgett	20	1972	cross-section	63.58	56		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	63.42	MATHEWS 3	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	63.42	MATHEWS 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	63.32	MATHEWS 1	IFIM Study	

Table 3. Index of Historical Cross-sections

Date of Survey	Agency	Author	Report Reference Number*	Report Date	Riffle/ Feature/ Cross Section	1997 USACE RM	Cross-section Code	Purpose	Comments
Jul-81	DWR - ND	Buer, Eaves	110	1982	Mathews Riffle	63.24			
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.10	A - A'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	63.08	I - I'	resurvey of USGS x/s	
1972	USGS	Blodgett	20	1972	cross-section	63.02	55		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	62.95	ALECK 3	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	62.90	ALECK 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	62.85	ALECK 1	IFIM Study	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Aleck Riffle	62.85			
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	62.79	J - J'	resurvey of USGS x/s	
Jul-81	DWR - ND	Buer, Eaves	110	1982	cross-section	62.75	Aleck Riffle		
1972	USGS	Blodgett	20	1972	cross-section	62.70	54		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	62.48	AT WESTERN RI	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	62.31	53		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	Great Western Riffle	62.22			
1972	USGS	Blodgett	20	1972	cross-section	62.17	52		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	61.49	50		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	61.28	51		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	61.17	ROBINSON 3	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	61.16	49		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	61.08	ROBINSON 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	61.08	ROBINSON 1	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	60.84	48		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	Robinson Riffle	60.71		spawning riffle	
					Levee Break	60.59			
1972	USGS	Blodgett	20	1972	cross-section	60.47	47		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	Steep Riffle	60.43		spawning riffle	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Weir Riffle	60.21		spawning riffle	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	60.14	WEIR 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	60.14	WEIR 1	IFIM Study	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Gateway Riffle	59.91		spawning riffle	
1972	USGS	Blodgett	20	1972	cross-section	59.73	46		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	59.30	45		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	58.75	44		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	58.74			for confidential use only (?) by DWR legal staff
					Thermalito Spillway	58.72			
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	58.33			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	58.28	43		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	Sutter Butte Riffle	58.24		spawning riffle	
1972	USGS	Blodgett	20	1972	cross-section	57.90	42		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	57.62			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	57.60	41		(these RM's are USGS footage adjusted to DWR RM's)
					Big Hole	57.42			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	57.41	40		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	57.32	CONVEYOR BLT 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	57.32	CONVEYOR BLT 1	IFIM Study	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Conveyor Belt Riffle	57.16		spawning riffle	
1972	USGS	Blodgett	20	1972	cross-section	57.08	39		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	56.73	38		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	56.50	37		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	56.20	HOUR 3	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	56.20	HOUR 2	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	56.20	HOUR 1	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	56.10	36		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	56.09			for confidential use only (?) by DWR legal staff
Jul-81	DWR - ND	Buer, Eaves	110	1982	Hour Riffle	56.03		spawning riffle	
1972	USGS	Blodgett	20	1972	cross-section	55.78	35		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	55.49	34		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	55.28			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	55.23	33.1		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	55.06	33		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	54.72	32		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	54.67	GOOSE 3	IFIM Study	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	54.57	GOOSE 2	IFIM Study	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Keister Riffle	54.43		spawning riffle	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	54.41	GOOSE 1	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	54.41	31		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	54.36			for confidential use only (?) by DWR legal staff
Jul-81	DWR - ND	Buer, Eaves	110	1982	Goose Riffle	54.25		spawning riffle	
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	54.06	BIG 3	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	54.03	30		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	53.70	29		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	53.65	BIG 2	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	53.44	28		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	53.39	BIG 1	IFIM Study	
Jul-81	DWR - ND	Buer, Eaves	110	1982	Big Riffle	53.32		spawning riffle	
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	53.14			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	53.12	27		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	cross-section	52.83	1A	Floodplain study	for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	52.81	26		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	52.49	25		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	52.43			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	52.21	24		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	cross-section	52.12	1B	Floodplain study	for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	51.90	23		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	---	51.80		spawning riffle	
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	51.61			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	51.57	22		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	51.20	21		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	50.89	20		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	50.62	19		(these RM's are USGS footage adjusted to DWR RM's)

Table 3. Index of Historical Cross-sections

Date of Survey	Agency	Author	Report Reference Number*	Report Date	Riffle/ Feature/ Cross Section	1997 USACE RM	Cross-section Code	Purpose	Comments
					Gridley Highway Bridge	50.55			
1972	USGS	Blodgett	20	1972	cross-section	50.55	18		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	50.47	17		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	50.39			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	50.38	16		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	50.15	15		(these RM's are USGS footage adjusted to DWR RM's)
					Gridley Riffle	49.90			
1972	USGS	Blodgett	20	1972	cross-section	49.83	14		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	49.29	13		(these RM's are USGS footage adjusted to DWR RM's)
Jul-81	DWR - ND	Buer, Eaves	110	1982	---	49.18		spawning riffle	
1972	USGS	Blodgett	20	1972	cross-section	48.67	12		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	48.42			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	47.93	11		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	47.60	10		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	47.39	9		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	47.13			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	46.88	8		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	46.73	SHALLOW 3	IFIM Study	
1968	DWR - CD	DWR - CD	140	1969	cross-section	46.64	7A	Floodplain study	for confidential use only (?) by DWR legal staff
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	46.64	SHALLOW 2	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	46.55	7		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	46.54	SHALLOW 1	IFIM Study	
					Herringer Riffle	46.35			
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	46.34			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	46.03	6		(these RM's are USGS footage adjusted to DWR RM's)
1972	USGS	Blodgett	20	1972	cross-section	45.68	5		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	45.65	HERRINGER 3	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	45.38	4		(these RM's are USGS footage adjusted to DWR RM's)
Jul-91	DWR-ND	Mendenhall,	145	1994	cross-section	45.15	HERRINGER 1	IFIM Study	
1972	USGS	Blodgett	20	1972	cross-section	45.13	3		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	45.05			for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	44.69	2		(these RM's are USGS footage adjusted to DWR RM's)
1968	DWR - CD	DWR - CD	140	1969	cross-section	44.66	11	Floodplain study	for confidential use only (?) by DWR legal staff
1972	USGS	Blodgett	20	1972	cross-section	44.32	1		(these RM's are USGS footage adjusted to DWR RM's)
					Honcut Creek	44.32			End of DWR 1981 Study
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	44.06			for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	cross-section	43.86	16	Floodplain study	for confidential use only (?) by DWR legal staff
May-94	DWR-LRW	Sommers?	95	1994	cross-section	43.65			survey from levee to levee
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	43.15			for confidential use only (?) by DWR legal staff
May-94	DWR-LRW	Sommers?	95	1994	cross-section	39.60			survey from levee to levee
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	38.08			for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	37.98			for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	cross-section	36.76	20A	Floodplain study	for confidential use only (?) by DWR legal staff
May-94	DWR-LRW	Sommers?	95	1994	cross-section	34.53			survey from levee to levee
1968	DWR - CD	DWR - CD	140	1969	cross-section	34.02	23	Floodplain study	for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	33.52			for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	cross-section	31.49	26	Floodplain study	for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	30.78			for confidential use only (?) by DWR legal staff
May-94	DWR-LRW	Sommers?	95	1994	cross-section	29.46			survey from levee to levee
(1990)	RCE	Ayres	15	1997	cross-section	28.75			
(1990)	RCE	Ayres	15	1997	cross-section	28.70	FR-1	RCE field survey	Used USGS quad sheet for overbanks
(1990)	RCE	Ayres	15	1997	cross-section	28.32			Estimated from field survey (FR-1)
(1990)	RCE	Ayres	15	1997	Route 20 Bridge	28.32			Estimated from field survey (FR-1)
(1990)	RCE	Ayres	15	1997	cross-section	28.31			Estimated from field survey (FR-1)
(1990)	RCE	Ayres	15	1997	cross-section	28.30			Estimated from field survey (FR-1)
1912	CDC	Ayres	15	1997	cross-section	28.25			
(1990)	RCE	Ayres	15	1997	cross-section	28.14			Estimated from field surveys (FR-2 and FR-1)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage	28.05			for confidential use only (?) by DWR legal staff
(1990)	RCE	Ayres	15	1997	cross-section	27.97			Estimated from field surveys (FR-2 and FR-1)
(1990)	RCE	Ayres	15	1997	5th Street Bridge	27.97			Estimated from field surveys (FR-2 and FR-1)
(1990)	RCE	Ayres	15	1997	cross-section	27.96			Estimated from field surveys (FR-2 and FR-1)
(1990)	RCE	Ayres	15	1997	cross-section	27.96			Estimated from field surveys (FR-2 and FR-1)
(1990)	RCE	Ayres	15	1997	cross-section	27.55			Estimated from field surveys (FR-2 and FR-1)
(1990)	RCE	Ayres	15	1997	Yuba River	26.97			
1912	CDC	Ayres	15	1997	cross-section				
1924	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-2	RCE field survey	Used USGS quad sheet for overbanks
1992	RCE	Ayres	15	1997	cross-section				
1912	CDC	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	Shanghai Bend		FR-3	RCE field survey	Used USGS quad sheet for overbanks
1912	CDC	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1912	CDC	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	Crest of Knickpoint				Estimated from field survey (FR-4) and profile survey
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
(1990)	RCE	Ayres	15	1997	cross-section		FR-4	RCE field survey	Used USGS quad sheet for overbanks
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1968	DWR - CD	DWR - CD	140	1969	cross-section		34	Floodplain study	for confidential use only (?) by DWR legal staff
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-5	RCE field survey	Used USGS quad sheet for overbanks
1912	CDC	Ayres	15	1997	cross-section				
1912	CDC	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-6	RCE field survey	Used USGS quad sheet for overbanks
1924	USACE	Ayres	15	1997	cross-section				

Table 3. Index of Historical Cross-sections

Date of Survey	Agency	Author	Report Reference Number*	Report Date	Riffle/ Feature/ Cross Section	1997 USACE RM	Cross-section Code	Purpose	Comments
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1912	CDC	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-7	RCE field survey	Used USGS quad sheet for overbanks
1992	RCE	Ayres	15	1997	cross-section				
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-8	RCE field survey	Used USGS quad sheet for overbanks
1992	RCE	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
(1990)	RCE	Ayres	15	1997	Star Bend		FR-9	RCE field survey	Used USGS quad sheet for overbanks
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-10	RCE field survey	Used USGS quad sheet for overbanks
1924	USACE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-11	RCE field survey	Used USGS quad sheet for overbanks
1912	CDC	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-12	RCE field survey	Used USGS quad sheet for overbanks
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-13	RCE field survey	Used USGS quad sheet for overbanks
1924	USACE	Ayres	15	1997	cross-section				
1912	CDC	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	cross-section		38	Floodplain study	for confidential use only (?) by DWR legal staff
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-15	RCE field survey	Used USGS quad sheet for overbanks
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section				Estimated from field survey (FR-16)
(1990)	RCE	Ayres	15	1997	cross-section				Estimated from field survey (FR-16)
(1990)	RCE	Ayres	15	1997	Nicolaus Bridge				Estimated from field survey (FR-16)
(1990)	RCE	Ayres	15	1997	cross-section				Estimated from field survey (FR-16)
(1990)	RCE	Ayres	15	1997	cross-section				Estimated from field survey (FR-16)
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section		FR-16	RCE field survey	Used USGS quad sheet for overbanks
1912	CDC	Ayres	15	1997	cross-section				
(1990)	RCE	Ayres	15	1997	cross-section			RCE field survey (channel,	Used USGS quad sheet for overbanks
(1990)	RCE	Ayres	15	1997	cross-section				Estimated from adjacent cross sections
May-94	DWR-LRW	Sommers?	95	1994	cross-section				survey from levee to levee
(1990)	RCE	Ayres	15	1997	Sutter Bypass		FR-17	RCE field survey	Used USGS quad sheet for overbank
1912	CDC	Ayres	15	1997	cross-section				
1924	USACE	Ayres	15	1997	cross-section				
1992	RCE	Ayres	15	1997	cross-section				
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
(1990)	RCE	Ayres	15	1997	cross-section			2D study for Sutter Bypass	
(1990)	RCE	Ayres	15	1997	cross-section			2D study for Sutter Bypass	
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
May-94	DWR-LRW	Sommers?	95	1994	cross-section				survey from levee to levee
1968	DWR - CD	DWR - CD	140	1969	DWR Staff Gage				for confidential use only (?) by DWR legal staff
					Junction w/ Sacramento				

BRIDGE	TRIBUTARY	FEATURE	
RIFFLE	SAMPLING LOCATION		

* REFERENCES	
15	
20	USGS - Blodgett - "Determination of the Channel Capacity of the Feather River between Oroville and Honcut Creek"
95	
110	
135	
140	
145	

5.1.1.5 Hydrologic Data

"Hydrologic data will be compiled."

(In Progress)

Table 4. Index of Hydrological and Meteorological Data

Facilities	ata Descripti	Map ID	Date		Notes	Sources	Gage ID	Gage Location		Electronic	Hardcopy
			Start	End				Latitude	Longitude		
Lake Oroville	Bathymetry	-	-	-	Bathymetry Map	Fish n Map CO.	-	-	-	-	X
		-	-	-	Area Capacity Table	DWR	-	-	-	-	X
	Geometry	-	-	-	Palmero Outlet-Section-Oroville Dam	DWR	-	-	-	-	X
		-	-	-	Flood Control Outlet-Cross Section-Oroville Dam	DWR	-	-	-	-	X
		-	-	-	Flood Control Outlet-Plan and Elevation-Oroville Dam	DWR	-	-	-	-	X
	ean Daily Flow D	10	1967	1968	Computed Inflow To Lake Oroville	USGS	11406798	39:32:06	121:28:26	X	-
		10	1967	1974	Computed Inflow To Lk Oroville	USGS	11406799	39:32:06	121:28:26	X	-
		11	1970	1971	Edward Hyatt Powerplant Nr Oroville	USGS	11406821	39:32:01	121:29:12	X	-
		11	1970	1971	Edward Hyatt Powerplant Nr Oroville	USGS	11406822	39:32:01	121:29:12	X	-
		10	1970	present	Hyatt Ph Nr Oroville	USGS	11406820	39:32:08	121:28:27	X	-
		10	1974	present	Hyatt Ph Power Release Nr Oroville	USGS	11406818	39:32:08	121:28:27	X	-
		10	1974	present	Hyatt Ph Pumpback Nr Oroville	USGS	11406819	39:32:08	121:28:27	X	-
		10	1974	1975	Hyatt Powerplant Power Release Near Oroville	USGS	11406817	39:32:08	121:28:27	X	-
		10	1967	present	Lk Oroville Nr Oroville	USGS	11406800	39:32:00	121:28:25	X	-
		11	1968	present	Palermo Cn A Oroville Dam	USGS	11406810	39:31:59	121:28:55	X	-
	recipitation Accu	12	1/1/1984	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
		-	10/1/1939	9/1/1991	Oroville RS - Monthly	CDEC	ORS	-	-	X	-
	cipitation, Increm	12	1/1/1987	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
	Reservior Elevatic	12	2/14/1985	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
		12	1/1/1984	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
	Reservior Release	-	-	-	-	-	-	-	-	-	-
	Reservior Storag	12	2/13/1985	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
		12	1/1/1984	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
		12	10/1/1967	present	Oroville Dam - Monthly	CDEC	ORO	39:31:59	121:31:01	X	-
	ervior, Storage Ch	12	10/1/1993	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
	oration, Lake Cor	12	10/1/1994	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
		-	10/1/1985	present	Oroville-Thermalito - Monthly	CDEC	ORT	-	-	X	-
	Reservior Inflows	12	1/1/1994	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
		12	1/23/1997	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
		-	1/1/1973	1/1/1979	Oroville Dam - Daily	DWR	-	-	-	-	X
		-	1/1/1979	present	Oroville Dam - Daily	DWR	-	-	-	X	-
	Reservior Outflow	12	1/5/1987	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
		12	2/6/1998	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
	ior, Top Conserv.	12	10/20/2000	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
	arge, Control Reg	12	2/5/1998	present	Oroville Dam - Hourly	CDEC	ORO	39:31:59	121:31:01	X	-
	Flow, Full Natura	12	4/21/1985	present	Oroville Dam - Daily	CDEC	ORO	39:31:59	121:31:01	X	-
	Air Temperature	-	4/1/2002	present	Max/Min - Daily	DWR	-	-	-	X	-
	Vater Temperatu	-	4/1/2002	present	Max/Min - Daily	DWR	-	-	-	X	-
		-	1/1/1997	present	Oroville Dam - Hourly	DWR	-	-	-	X	-
		-	3/1/2002	present	HY1_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	HY2_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	HY3_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	HY4_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	HY5_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	HY6_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	Lat_Lateral_Canal_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_612	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_630	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_649	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_668	DWR	-	-	-	X	-
	Vater Temperatu	-	3/1/2002	present	Ori_Water_Temp_As_Elev_686	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_705	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_723	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_742	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_751	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_761	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_770	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_779	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_789	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_798	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_807	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_816	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_826	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_835	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_844	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_854	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_863	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_872	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_882	DWR	-	-	-	X	-
		-	3/1/2002	present	Ori_Water_Temp_As_Elev_891	DWR	-	-	-	X	-
		-	3/1/2002	present	Osw_Hyatt_Tailrace_Water_Temp_#2	DWR	-	-	-	X	-
		-	3/1/2002	present	Osw_Hy_Tailrace_Water_Temp	DWR	-	-	-	X	-

Table 4. Index of Hydrological and Meteorological Data

Facilities	ata Descripti	Map ID	Date		Notes	Sources	Gage ID	Gage Location		Electronic	Hardcopy
			Start	End				Latitude	Longitude		
	Diversion Flows	-	-	-	-	-	-	-	-	-	-
	ccretion / Depleti	-	-	-	-	-	-	-		-	-
Thermalito Diversion Pool	Bathymetry	-	-	-	Area Capacity Table	DWR	-	-	-	-	X
	Geometry	-	-	-	Thermalito Diversion Dam-Cross Section	DWR	-	-	-	-	X
	ean Daily Flow Dat		1970	1971	Thermalito Diversion Pool Nr Oroville,	USGS	11406825	39:31:46	121:32:44	X	-
	recipitation Accu	-	-	-	-	-	-	-	-	-	-
	cipitation, Increm	-	-	-	-	-	-	-	-	-	-
	Reservior Elevatic	-	-	-	-	-	-	-	-	-	-
	Reservior Release	-	-	-	-	-	-	-	-	-	-
	Reservior Storag	19	10/1/1969	present	Thermalito Diversion Pool - Monthly	CDEC	THD	39:27:29	121:38:17	X	-
	Reservior Inflows	-	-	-	-	-	-	-	-	-	-
	Reservior Outflow	-	-	-	-	-	-	-	-	-	-
	Water Temperatu	-	3/1/2002	present	Diversion_Pool_Water_Temp	DWR					
	Diversion Flows	-	-	-	-	-	-	-	-	-	-
	ccretion / Depleti	-	-	-	-	-	-	-	-	-	-
Thermalito Forebay	Bathymetry	-	-	-	Area Capacity Table	DWR	-	-	-	-	X
		-	-	-	Area Capacity Curve	DWR	-	-	-	-	X
	Geometry	-	-	-	Thermalito Forebay Dam-Typical Embankment Section	DWR	-	-	-	-	X
	ean Daily Flow D	16	1970	present	Thermalito Ph Nr Oroville	USGS	11406850	39:30:53	121:37:43	X	-
		16	1974	present	Thermalito Ph Pumpback Nr Oroville	USGS	11406849	39:30:53	121:37:43	X	-
		16	1974	present	Thermalito Power Release Nr Oroville	USGS	11406848	39:30:53	121:37:43	X	-
		16	1974	1975	Thermalito Powerplant Power Release Nr Oroville	USGS	11406847	39:30:53	121:37:43	X	-
	Reservior Elevatic	-	-	-	-	-	-	-	-	-	-
	Reservior Release	-	-	-	-	-	-	-	-	-	-
		-									
	Reservior Storag	16	10/1/1969	present	Thermalito Forebay - Monthly	CDEC	TFB	39:27:29	121:38:17	X	-
		16	1971	present	Thermalito Forebay Nr Orovill@2400	USGS	11406840	39:30:56	121:37:44	X	-
	Reservior Elevatic	-	-	-	-	-	-	-	-	-	-
	Reservior Release	-	-	-	-	-	-	-	-	-	-
	Reservior Inflows	-	-	-	-	-	-	-	-	-	-
	Reservior Outflow	-	-	-	-	-	-	-	-	-	-
	Water Temperatu	-	3/1/2002	present	TH1_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	TH2_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	TH3_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	TH4_Cooling_Water_Supply_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	THP_Headworks_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	THP_Tailrace_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	TPC_Power_Canal_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	R_O Canal Water Temperature	DWR	-	-	-	X	-
		-	3/1/2002	present	W_C Canal Water Temperature	DWR	-	-	-	X	-
	ow, Canal Divers	16	10/1/1985	present	Thermalito Forebay	CDEC	TFB	39:27:29	121:38:17	X	-
	ccretion / Depleti	-	-	-	-	-	-	-		-	-
	Bathimetry	-	-	-	Area Capacity Table	DWR	-	-	-	-	X
		-	-	-	Area Capacity Curve	DWR	-	-	-	-	X
	Geometry	-	-	-	Miscellaneous Facilities	DWR	-	-	-	-	X
		-	-	-	Tail Channel	DWR	-	-	-	-	X
		-	-	-	Richvale - Western Outlet	DWR	-	-	-	-	X
		-	-	-	P.G.& E Outlet	DWR	-	-	-	-	X
		-	-	-	Sutter- Butte Outlet	DWR	-	-	-	-	X
		-	-	-	Feather River Outlet	DWR	-	-	-	-	X
	ean Daily Flow D	19	1967	present	Thermalito Afterbay Release To Feather R	USGS	11406920	39:27:23	121:38:10	X	-
		18	1968	present	PG&E Lateral A Intake Nr Oroville	USGS	11406900	39:29:22	121:41:12	X	-
		17	1968	present	Richvale Cn A Intake Nr Oroville	USGS	11406890	39:30:19	121:41:06	X	-
		20	1967	present	Sutter Butte Cn A Intake Nr Oroville	USGS	11406910	39:27:02	121:39:26	X	-
	Reservior Elevatic	-	-	-	-	-	-	-	-	-	-
	Reservior Release	-	-	-	-	-	-	-	-	-	-
	Reservior Storag	19	1/1/1985	present	Thermalito Afterbay - Daily	CDEC	TAB	39:27:29	121:38:17	X	-
		19	10/1/1967	present	Thermalito Afterbay - Monthly	CDEC	TAB	39:27:29	121:38:17	X	-
		19	10/1/1969	present	Thermalito Total - Monthly	CDEC	TMT	39:27:29	121:38:17	X	-
		19	1967	present	Thermalito Afterbay Nr Oroville @2400	USGS	11406870	39:27:30	121:38:17	X	-
	Reservior Inflows	-	-	-	-	-	-	-	-	-	-
	Reservior Outflow	-	-	-	-	-	-	-	-	-	-
	Air Temperature	-	4/1/2002	present	Max/Min - Daily	DWR	-	-	-	X	-
	Water Temperatu	-	4/1/2002	present	Max/Min - Daily	DWR	-	-	-	X	-
		-	3/1/2002	present	Sutter_Butte_Canal_Water_Temp	DWR	-	-	-	X	-
	Diversion Flows	-	-	-	-	-	-	-	-	-	-
	ccretion / Depleti	-	-	-	-	-	-	-	-	-	-
Thermalito Diversion Dam	Bathymetry	-	-	-	Area Capacity Curve	DWR	-	-	-	-	X
	Geometry	-	-	-	Isometric Plan	-	-	-	-	-	X
		-	-	-	Cross Section	-	-	-	-	-	X
	ean Daily Flow D	-	-	-	-	-	-	-	-	-	-
	Water Elevation	-	-	-	-	-	-	-	-	-	-
	Water Releases	-	-	-	-	-	-	-	-	-	-
	Diversion Flows	-	-	-	-	-	-	-	-	-	-
	Water Temperatu	-	-	-	-	-	-	-	-	-	-
	ccretion / Depleti	-	-	-	-	-	-	-	-	-	-

Table 4. Index of Hydrological and Meteorological Data

Facilities	ata Descriptio	Map ID	Date		Notes	Sources	Gage ID	Gage Location		Electronic	Hardcopy
			Start	End				Latitude	Longitude		
Fish Barrier Dam	Bathymetry	-	-	-	-	-	-	-	-	-	-
	Geometry	-	-	-	-	-	-	-	-	-	-
	ean Daily Flow D	14	1973	present	Div. To Feather R Fish Hatchery Nr Oroville	USGS	11406930	39:31:13	120:32:48	X	-
	recipitation Accu	15	10/1/1989	5/1/1994	Oroville Fish Hatchery - Monthly	CDEC	ORF	39:31:01	121:33:00	X	-
	Water Elevation	-	-	-	-	-	-	-	-	-	-
	Water Releases	-	-	-	-	-	-	-	-	-	-
	Diversion Flows	-	-	-	-	-	-	-	-	-	-
	Vater Temperatu	-	3/1/2002	present	FBD_Fish_Barrier_Canal_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	FBD_Fish_Barrier_Canal_Water_Temp	DWR	-	-	-	X	-
		-	3/1/2002	present	F_H_Water_Temp	DWR	-	-	-	X	-
	ccretion / Depleti	-	-	-	-	-	-	-	-	-	-
Feather River Channels	Bathymetry	-	-	-	-	-	-	-	-	-	-
	Geometry	-	-	-	-	-	-	-	-	-	-
	ean Daily Flow D	29	1967	1973	Combined Flow Fall R Plus Sucker Run W B Feather	USGS	11405301	39:47:12	121:33:42	X	-
		3	1967	1973	Combined Flow Feather R Merrimac Plus S F Feather	USGS	11396351	39:42:30	121:16:10	X	-
		30	1967	1983	Combined Flow N F Feather R Pulga + Poe PP	USGS	11404901	39:47:39	121:27:03	X	-
		27	1942	1985	Feather R Nr Nicolaus	USGS	11425000	38:54:01	121:35:00	X	-
		27	1974	1984	Feather R Nr Nicolaus Routed Flow	USGS	11425001	38:54:01	121:35:00	X	-
		9	1911	1964	Feather R A Bidwell Bar Ca	USGS	11397500	39:33:15	121:26:15	X	-
		14	1901	present	Feather R A Oroville	USGS	11407000	39:31:13	121:32:48	X	-
		14	1973	present	Feather R A Oroville R Only	USGS	11406999	39:31:13	121:32:48	X	-
		23	1964	1984	Feather R A Yuba City	USGS	11407700	39:08:20	121:36:17	X	-
		9	1911	1955	Feather R At Bidwell Bar At Enterprise + Palermo	USGS	11397501	39:33:15	121:26:15	X	-
		25	1969	1980	Feather R At Shangai Bend Nr Oliverhurst	USGS	11421700	39:04:44	121:36:08	X	-
		25	1976	1984	Feather R At Shangai Bend Nr Oliverhurst	USGS	11421701	39:04:44	121:36:08	X	-
		21	1964	1997	Feather R Nr Gridley	USGS	11407150	39:22:00	121:38:46	X	-
		42	1910	1927	MF Feather R A Sloat	USGS	11393000	39:51:25	120:43:05	X	-
		41	1941	1962	MF Feather R BL Sloat	USGS	11393500	39:52:00	120:46:15	X	-
		43	1925	1979	MF Feather R NR Clio	USGS	11392500	39:45:14	120:35:42	X	-
		3	1951	1986	MF Feather R NR Merrimac	USGS	11394500	39:42:30	121:16:10	X	-
		40	1923	1932	MF Feather R NR Nelson Point	USGS	11394000	39:51:10	120:52:20	X	-
		-	1968	1980	MF Feather R NR Portola	USGS	11392100	39:43:13	120:26:26	X	-
		2	1905	1910	NF Feather R A Big Bend	USGS	11405000	39:42:52	121:28:05	X	-
		30	1911	present	NF Feather R A Pulga	USGS	11404500	39:47:39	121:27:03	X	-
		38	1968	present	NF Feather R BL Belden Dam	USGS	11401112	40:04:17	121:09:49	X	-
		32	1978	present	NF Feather R BL Grizzly C	USGS	11404330	39:51:09	121:23:29	X	-
		31	1975	present	NF Feather R BL Poe Dam	USGS	11404400	39:48:25	121:26:05	X	-
		36	1978	present	NF Feather R BL Rock C Div. Dam	USGS	11403200	39:58:49	121:16:33	X	-
	ean Daily Flow D	-	1906	present	NF Feather R NR Prattville	USGS	11399500	40:10:06	121:05:31	X	-
		-	1911	1966	SF Feather R A Enterprise	USGS	11397000	39:32:15	121:20:45	X	-
		-	1911	1961	SF Feather R A Enterprise + Palerma Canal	USGS	11397001	39:32:15	121:20:45	X	-
		7	1962	1989	SF Feather R A Ponderosa Dam	USGS	11396350	39:32:52	121:18:11	X	-
		35	1960	1979	SF Feather R AB Little Grass Valley Res.	USGS	11394800	39:45:07	120:57:26	X	-
		4	1960	present	SF Feather R BL Div. Dam Nr Strawberry Valley	USGS	11395200	39:38:51	121:07:04	X	-
		5	1962	present	SF Feather R BL Forbestown Dam	USGS	11396200	39:33:05	121:12:30	X	-
		34	1927	present	SF Feather R BL Little Grass Valley Dam	USGS	11395030	39:46:26	121:01:16	X	-
		6	1957	1961	SF Feather R NR Forbestown	USGS	11396300	39:33:08	121:16:49	X	-
		33	1986	present	WB Feather R Bl Hendricks Div. Dam	USGS	11405200	39:56:03	121:31:43	X	-
		37	1993	1994	WB Feather R Bl Snag Lk Nr Jonesville	USGS	11405085	40:04:24	121:27:08	X	-
		29	1957	1986	WB Feather R Nr Paradise	USGS	11405300	39:47:12	121:33:42	X	-
		1	1930	1963	WB Feather R Nr Yankee Hill	USGS	11406500	39:41:55	121:33:38	X	-
		3	1/1/1993	present	Feather River at Merrimac	CDEC	MER	39:42:32	121:16:12	X	-
		21	1/1/1993	present	Feather River Near Gridley	CDEC	GRL	39:22:01	121:38:46	X	-
	River Stage	26	10/2/1997	present	Feather River at Boyd's Landing - Hourly	CDEC	FBL	39:02:42	121:36:40	X	-
		22	10/7/1997	present	Feather River at Live Oak - Hourly	CDEC	FLO	39:14:53	121:38:10	X	-
		3	1/5/1984	present	Feather River at Merrimac - Hourly	CDEC	MER	39:42:32	121:16:12	X	-
		24	1/1/1984	present	Feather River at Yuba City - Hourly	CDEC	YUB	39:07:59	121:36:00	X	-
		21	1/1/1984	present	Feather River Near Gridley - Hourly	CDEC	GRL	39:22:01	121:38:46	X	-
		28	1/1/1984	present	Feather River Near Nicolaus - Hourly	CDEC	NIC	38:53:28	121:36:14	X	-
		30	3/18/1998	present	North Fork Feather River at Pulga - Hourly	CDEC	PLG	39:47:38	121:27:04	X	-
	recipitation Accu	28	10/1/1962	present	Feather River Near Nicolaus -Monthly	CDEC	NIC	38:53:28	121:36:14	X	-
	Vater Content, Sn	-	4/1/1930	present	Feather River Meadow - Monthly	CDEC	FEM	40:21:18	121:25:19	X	-
	Snow Depth	-	4/2/1930	present	Feather River Meadow - Monthly	CDEC	FEM	40:21:18	121:25:19	X	-
	River Discharge	3	1/5/1984	present	Feather River at Merrimac - Hourly	CDEC	MER	39:42:32	121:16:12	X	-
		21	1/1/1984	present	Feather River Near Gridley - Hourly	CDEC	GRL	39:22:01	121:38:46	X	-
		30	3/18/1998	present	North Fork Feather River at Pulga - Hourly	CDEC	PLG	39:47:38	121:27:04	X	-
	Flow, Full Natura	30	10/1/1925	8/1/1992	Feather MF Near Clio - Monthly	CDEC	FTC	39:45:14	120:35:42	X	-
		3	10/1/1907	9/1/1970	Feather MF Near Merrimac - Monthly	CDEC	FTM	39:42:32	121:16:12	X	-
		30	10/1/1900	present	Feather NF at Pulga - Monthly	CDEC	FPL	39:47:38	121:27:04	X	-
		39	2/1/1905	present	Feather NF Near Prattville - Monthly	CDEC	FPR	40:10:08	121:05:28	X	-
		14	10/1/1905	present	Feather R - Monthly	CDEC	FTO	39:31:19	121:32:49	X	-
		-	10/1/1900	present	Feather SF at Ponderosa - Monthly	CDEC	FTP	-	-	X	-
	ow, Monthly Volu	43	10/1/1925	10/1/1925	Feather MF Near Clio	CDEC	FTC	39:45:14	120:35:42	X	-
		3	10/1/1907	10/1/1907	Feather MF Near Merrimac	CDEC	FTM	39:42:32	121:16:12	X	-
		30	1/1/1990	present	Feather NF at Pulga	CDEC	FPL	39:47:38	121:27:04	X	-
		14	1/1/1905	present	Feather R - Monthly	CDEC	FTO	39:31:19	121:32:49	X	-
		-	1/1/1990	present	Feather SF at Ponderosa	CDEC	FTP	-	-	X	-
		39	1/1/1905	present	Feather NF Near Prattville	CDEC	FPR	40:10:08	121:05:28	X	-
	ow, Canal Divers	-	10/1/1905	present	Feather River - Monthly	CDEC	FTT	-	-	X	-
		14	3/1/2001	present	Feather R - Daily	CDEC	FTO	39:31:19	121:32:49	X	-
	ow, Irrig&Consum	30	1/1/1990	present	Feather NF at Pulga - Monthly	CDEC	FPL	39:47:38	121:27:04	X	-
		14	10/1/1985	present	Feather R - Monthly	CDEC	FTO	39:31:19	121:32:49	X	-
	arge, Control Reg	-	9/21/1999	present	Total Release-Feather R blw Thermalito - Daily	CDEC	THA	39:31:59	121:31:01	X	-
		-	2/5/1998	present	Total Release-Feather R blw Thermalito -Hourly	CDEC	THA	39:31:59	121:31:01	X	-
	Water Elevation	-	-	-	-	-	-	-	-	-	-
	Vater Temperatu	-	-	-	-	-	-	-	-	-	-
	ccretion / Depleti	-	-	-	-	-	-	-	-	-	-

5.1.2 Physiographic Setting

"Prepare a general description of the physiographic setting, including maps and descriptions of precipitation, geology, soils, topography, vegetation, and other watershed characteristics. Products will be compiled as part of the GIS database."

The Feather River watershed physiography and ecology are complex and sensitive to human activities. Elevation, slope and aspect, geology, soils, hydrology, climate, fire history, vegetation, and land use all vary and interact in complex relationships. For example, topography influences precipitation, thereby affecting vegetation and geomorphology.

5.1.2.1 Basin Setting and Morphology

The North Fork basin is roughly triangle shaped, oriented in the east-west direction, with a point of the triangle meeting the confluence of the Middle Fork in Lake Oroville (Figure ___). The basin's maximum length and width are 65 and 75 miles respectively.

Figure 3. Feather River Watershed

The widest segment of the watershed is along the Honey Lake escarpment on the northeast side. The East Branch North Fork Feather River is a major tributary. It drains high elevation valleys and joins with the North Fork near Belden on Highway 70.

The Middle Fork basin is roughly crescent- shaped. It is elongated along an east-west axis with its maximum length and width approximately 75 and 35 miles respectively.

The South Fork with a drainage area of about 132 square miles is much smaller. It skirts the southwest portion of the Feather River Watershed and mostly drains the lower foothills of the Sierra Nevada. The West Branch is also small, with 113 square miles of area at the gage at Enterprise.

The lower two-thirds of the Feather River watershed, both the Middle and North forks flow in deeply incised canyons with little or no floodplain. In the upper one-third, streams historically flowed in shallow meandering channels with broad floodplains covered with riparian vegetation. Floodwaters would quickly overtop the banks and deposit sediment on the valley floor. Under present conditions, land use changes have caused many of the headwater streams to lose their meander patterns and form into sharp V-shaped channels devoid of vegetation. The tall alluvial banks along these channels are easily eroded.

Sierra Valley, in the eastern portion of the Middle Fork watershed, is the largest basin (203 square miles) in the study area. Its shape is roughly circular, with smooth relief crossed by many weakly entrenched, meandering, and braided streams.

Table 5. Feather River Sub-watershed Areas

Watershed (above gaging station)	Area (miles^2)
North Fork@ Pulga	1,953
Middle Fork nr Merrimac	1,062
South Fork @ Enterprise	132
West Branch nr. Paradise	113
Lake Oroville nr. Oroville	3,607

The watershed above Oroville Reservoir drains an area of 3,611 square miles (DWR, 1993). The North Fork and Middle Fork Feather Rivers comprise 3,222 square miles of this area, including portions of the foothill and mountain regions of the northern Sierra Nevada and southern Cascade Range. The South Fork and the West Branch comprise the additional square 389 miles.

CHANNEL MORPHOLOGY

Stream length from the headwaters to Oroville Dam is approximately 135 miles along the North Fork and 120 miles along the Middle Fork Feather River (Figures 7 and 8). The complex topography governs stream morphology. Stream gradients are moderate in the upper portions of the watershed where streams cross montane meadows and valleys. Gradients increase as streams flow through deep, rugged canyons.

North Fork Feather River watershed has an area of 2,006 square miles and the Middle Fork 1,216 square miles. The channel morphologies are different and will be discussed separately.

5.1.2.1.1 North Fork Feather River

Elevations range from 10,000 feet on the southeast slope of Mt. Lassen, and drops to a minimum elevation of 900 feet at Lake Oroville. The upper portion has a number of basins with a mix of dense timber and montane meadows. The largest of these, about 39 square miles, was called Big Meadows until inundated by Lake Almanor.

The main channel between Lake Almanor and Lake Oroville flows through steep canyons as shown on the North Fork stream profile in Figure 5. The elevation drop of nearly 4,000 feet is fairly evenly distributed over the 65-mile distance. The form, slope, and behavior of this mostly bedrock channel are determined more by its geology than the quantity of water and sediment which it conveys (DWR, 1988). The channel has a pool-riffle configuration.

Four dams have been built in this reach for hydroelectric production. The high precipitation, large impoundment capabilities Lake Almanor, and the steep canyon below are major reasons for the extensive hydroelectric development.

The East Branch of the North Fork (1,031 $miles^2$) is a major tributary and drains the eastern part of the North Fork's watershed, from the Honey Lake Escarpment to its confluence with the North Fork Feather River near Belden on Highway 70. DWR's Antelope Lake is on Indian Creek, one of the East Branch tributaries. The East Branch has been identified as a major contributor of sediment, mainly because of differences in geology and soils, and extensive timber harvesting and grazing (PGE 1986; SCS, 1989).

Sources of bedload material have been the East Branch, other tributaries, and bank erosion since the construction of Lake Almanor in 1913. Large quantities of sand and silt enter the North Fork from the East Branch. These sediments accumulate in pools, on point bars, and behind dams (DWR, 1988). Reservoirs such as Rock Creek and Cresta on the North Fork trap most of the gravel-size and some of the sand- and silt-size sediment. According to a PG&E survey (1992), 4.4 million cubic yards of sediment have been deposited behind Rock Creek Dam in 34 years. This rate of deposition averages approximately 130,000 cubic yards per year. Typical of dammed rivers, stream channels below the reservoirs have become depleted in gravel and sand sizes and armored by cobbles and boulders.

The West Branch is a small watershed of about 113 square miles (at the gage near Paradise).

5.1.2.1.2 Middle Fork Feather River

The Middle Fork is approximately 108 miles long from its headwaters to Lake Oroville, as shown in Figure 6. The maximum elevation in the Middle Fork watershed is approximately 7,500 feet in the mountains bordering Sierra Valley, dropping to a minimum elevation of 900 feet at Lake Oroville. Channel gradient is low to moderate in the upper basin. Gradient increases dramatically in the lower reaches as the river flows through rugged, steep canyons. The Middle Fork became part of the National Wild and Scenic Rivers System in October 1968.

Sierra Valley is a 203 square mile valley, mostly developed for agriculture, in the upper part of the watershed. It is the largest valley in the study area. The valley is relatively flat and interwoven with a meandering, twisting pattern of creeks, irrigation ditches, and diversion channels. The main crop is alfalfa, but the valley is also used for dryland farming, grazing, irrigated crops, and pasture.

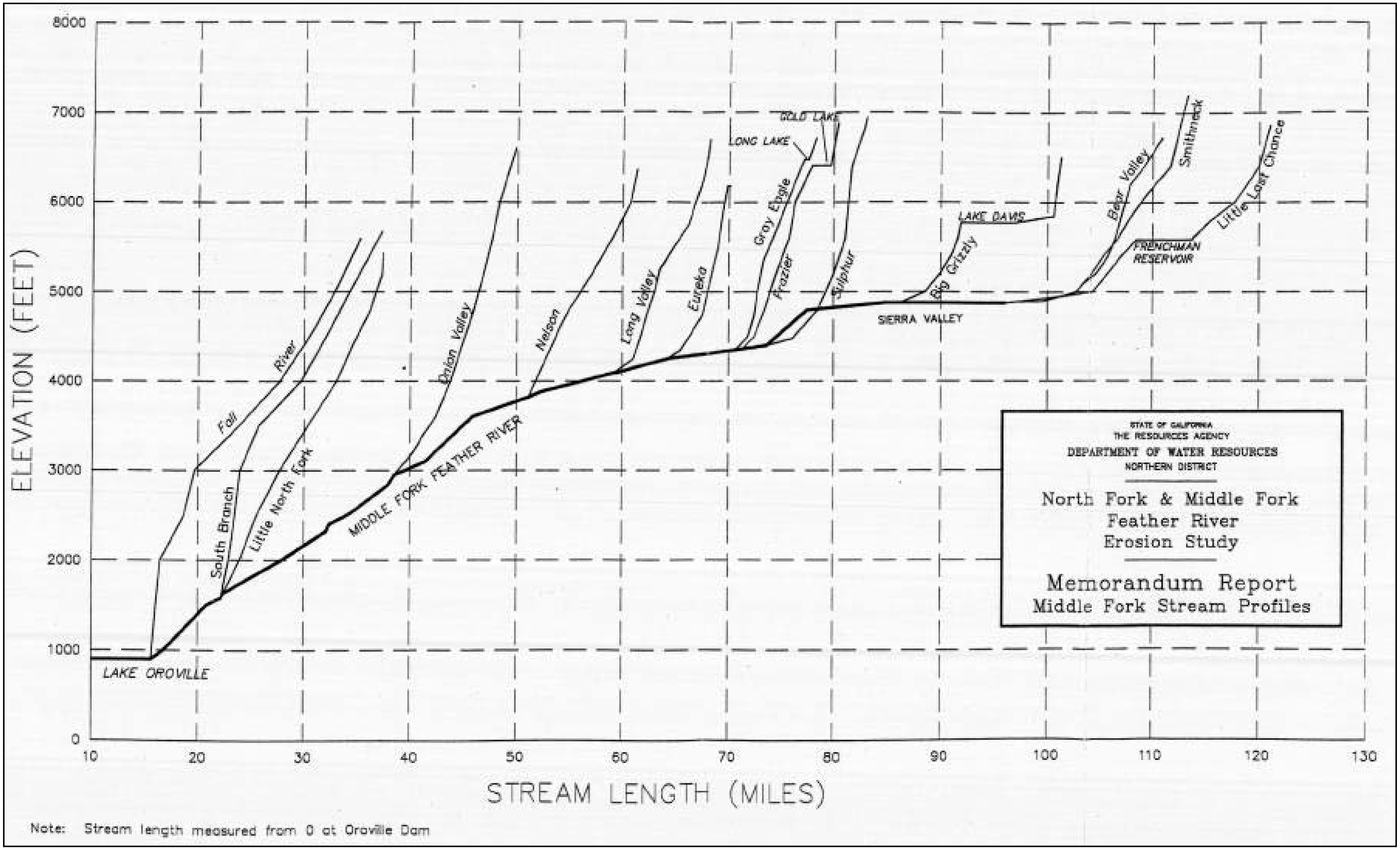
Unlike the North Fork, the Middle Fork has no system of hydroelectric projects upstream of Lake Oroville. Frenchman Lake and Lake Davis are the only major reservoirs and were constructed on tributaries as part of the State Water Project in the 1960s. Lake Davis was built to provide public recreation, enhance downstream fisheries and supply water for the city of Portola. Frenchman Reservoir provides reservoir recreation and irrigation water for Sierra Valley.

Downstream from the community of Sloat, the Middle Fork becomes a wild river as it flows approximately 45 miles through the Middle Fork Canyon. In places, the sides of the gorge rise one-half mile straight up from the gravel banks of the river. An average stream gradient of 62 feet per mile through this section has created numerous pools and riffles. The Middle Fork Feather River provides excellent habitat and is considered one of the best wild trout fisheries in California.

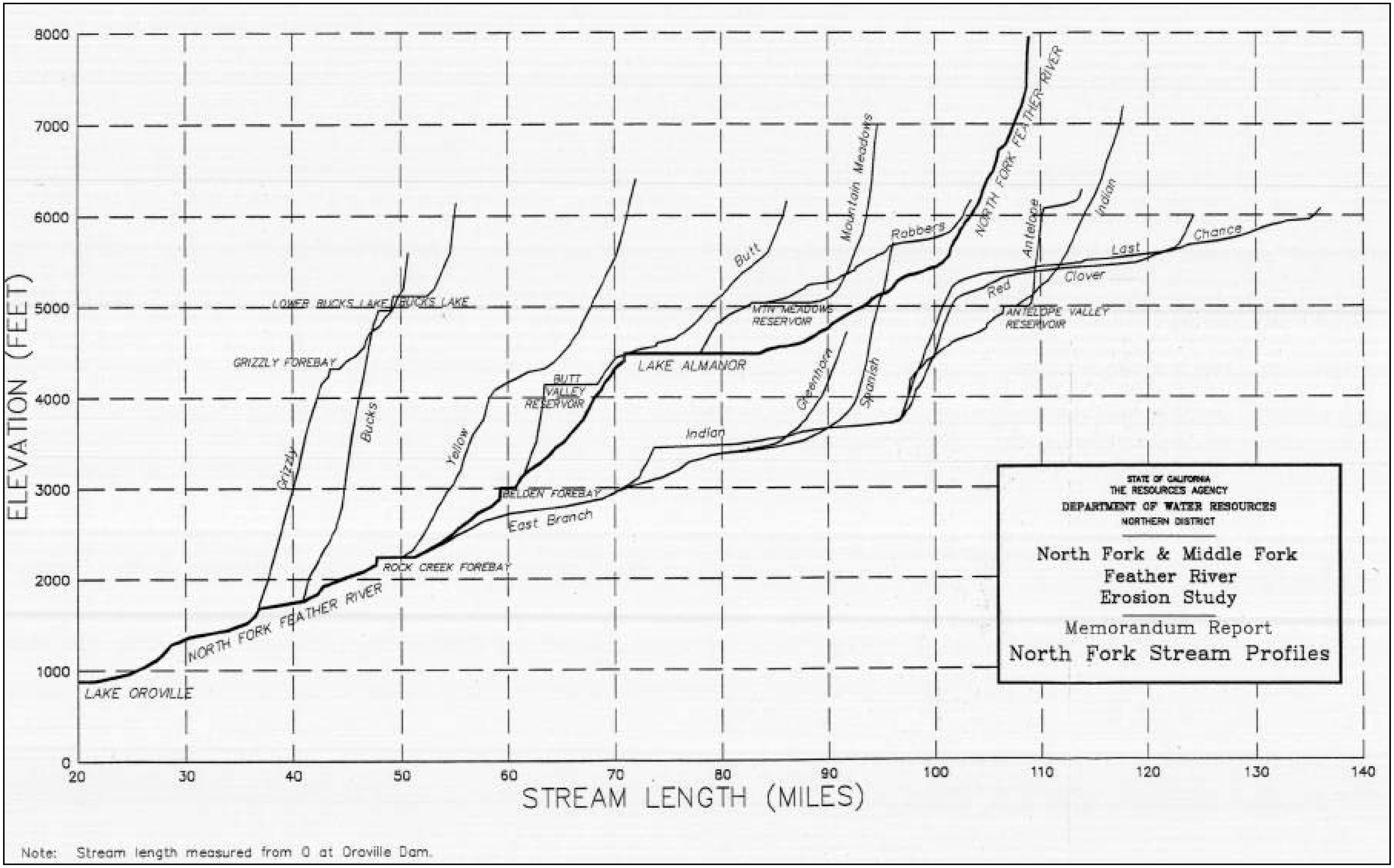
Little data has been compiled on erosion and sedimentation. Most erosion investigations have been conducted on the East Branch of the North Fork. With the lack of hydroelectric development, little incentive exists to gather information on flows, erosion or sedimentation. Streamflow data collection was discontinued at all United States Geological Survey (USGS) gaging stations by 1986. Conclusions about erosion and sedimentation in the Middle Fork Feather River watershed must be based on the minimal information available and comparisons to similar situations on the North Fork.

The Middle Fork watershed shares many characteristics with the North Fork including land use practices, precipitation patterns, vegetation, topography, and geology. Because of these similarities, watershed erosion and sediment transport rates are probably similar to those occurring in the North Fork watershed. Unlike the North Fork with numerous dams, diversions and power plants, sediment from the Middle Fork is not trapped by dams until arriving at Lake Oroville.

The South Fork Feather River enters the Middle Fork in Lake Oroville. The watershed area is 132 square miles at the Enterprise gage, 11 miles east of Oroville.



SP-G2 FEATHER RIVER GEOMORPHIC STUDY
Figure 4 - Middle Fork Stream Profile



SP-G2 FEATHER RIVER GEOMORPHIC STUDY

Figure 5 - North Fork Stream Profile

5.1.2.2 Topography

The Feather River watershed is complex, with numerous geologic formations, deeply incised canyons, broad alluvial valleys, many volcanic features, and steep forested slopes. The west-flowing upper Feather River system is unique because it is the only river which crosses the crest of the Sierra Nevada. The watershed above Lake Oroville can be divided into a western and eastern topographic area. This designation is used frequently by Plumas National Forest and refers to areas west and east of the Sierra Nevada crest. The two areas differ in topography, climate, vegetative communities, and forest productivity.

The western topographic area comprises the western slope of the Sierra Nevada, bounded on the west by the Sacramento Valley and on the east by the Sierran crest. The western slope averages about 50 miles wide, east to west, and consists of mountainous terrain incised by south-west trending, steep-sloped canyons with depths exceeding 3,000 feet. Narrow plateaus of moderate relief are located between the canyons and are the most productive timber land. The western slope rises on a 4 degree inclination from the Sacramento Valley to the crest. Maximum elevations along the crest range from about 7,000 to 7,500 feet.

The eastern topographic area is bounded by the Sierran crest on the west and the Honey Lake escarpment on the east. It is characterized by northwest-trending, fault-bounded mountains separated by down-thrown alluvial valleys. These parallel features are similar to those of the adjoining Basin and Range geomorphic province. Valley bottoms are typically open with broad meadows and grass land used for livestock grazing and agriculture. Under natural conditions, streams in these valleys maintain gentle gradients because they have shallow banks, considerable riparian vegetation and a tendency to meander. Elevations range in this zone from 2,100 to 7,700 feet.

Below Lake Oroville, the Feather River emerges from the Sierra Nevada and enters the Sacramento Valley. Here the stream gradient is less and the topography subdued. The topography is mostly flat, with the exception of overflow channels, multiple channel areas, and both artificial and natural leeves occurring along the river course. Honcut Creek, the Yuba River, and the Bear River join the Feather before entering the Sacramento River at Verona. Elevation of the valley floor varies from about 150 feet at Oroville to about 25 feet at Verona.

5.1.2.3 Climate

The Feather River basin has a Mediterranean type climate with hot, dry summers and cool wet winters. Dominating and controlling the weather of northern California is the semi-permanent, high pressure area of the mid-Pacific Ocean. This pressure center

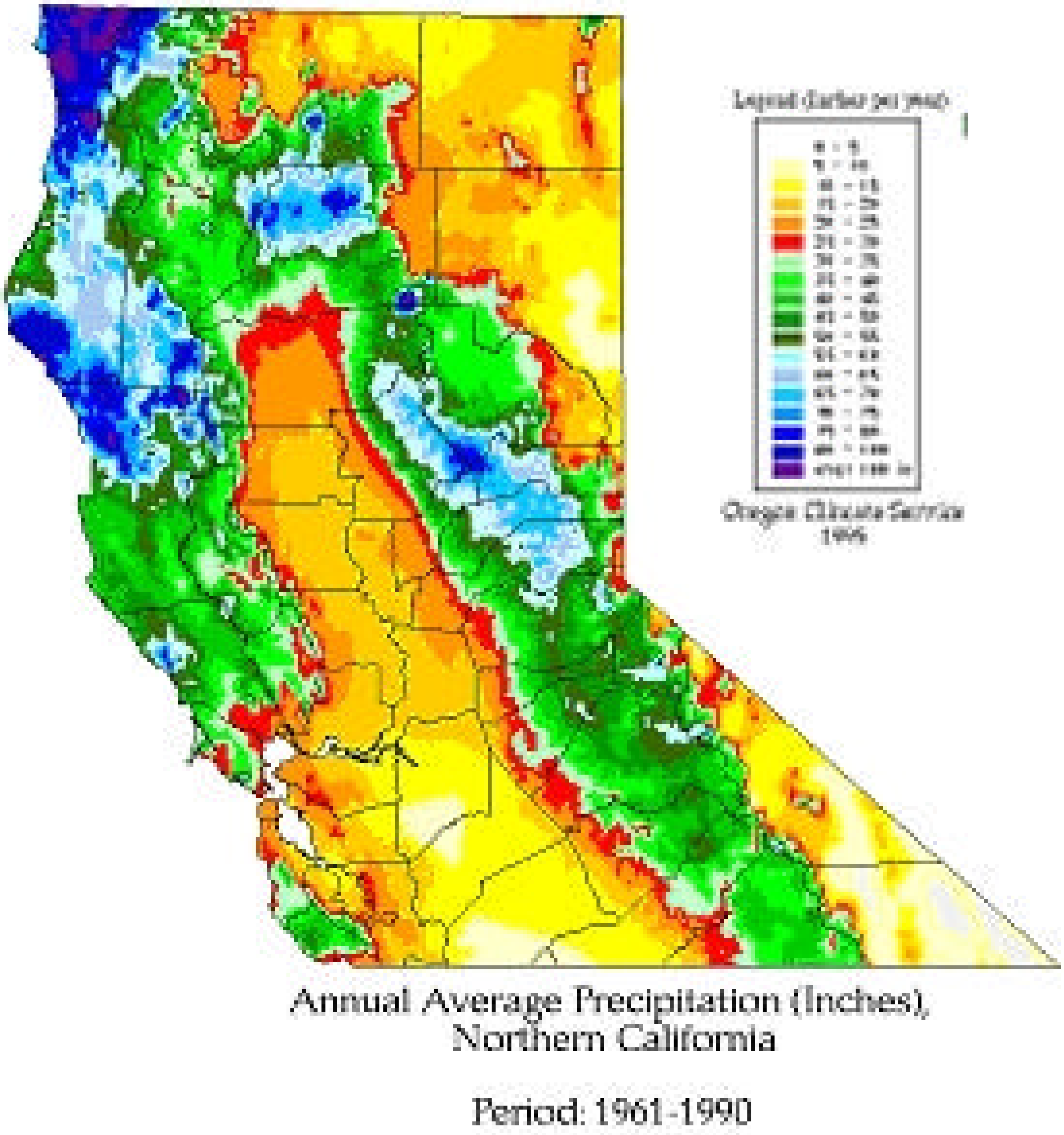


Figure 6. Isohyetal Map of Northern California

moves northward in summer, pushing storm tracks well to the north. In winter, it generally moves south, allowing storms to cross California. Frontal cyclonic storms generally occur from November through March. Rainfall in the watershed is shown on the isotheral map.

Rainfall within the watershed varies greatly because of topography and rain-shadow effects. The western part of the watershed intercepts winter moisture-laden air from the Pacific Ocean. Orographic effects result in an
average increase of two to six inches for each 300-foot rise in elevation. Precipitation ranges from about 50 inches at Lake Oroville to 90 inches in the high mountains overlooking the Lake and in the upper end of the North Fork Feather River.

Rain-shadow effects limit precipitation within the southeastern part of the watershed. This is drained by the Middle Fork Feather River. Annual precipitation varies from 15 to 40 and averages about 30 inches within the shadow area. About 50 percent of the precipitation occurs as snow, providing streamflow during the months of April, May, and June.

5.1.2.4 Vegetation

Vegetation is generally dependent on elevation, temperature and precipitation and also varies according to slope, aspect, soils, fire history and land use practices. Chaparral plants such as ceonothus, manzanita, chamise, oak species, and blackjack pine grow at elevations below 2,000 feet. Mixed conifer forests containing Jeffrey pine, ponderosa pine, Douglas fir, incense cedar, white fir, red fir, and sugar pine grow at higher elevations. Elevation provides a general control of vegetation type but some plants such as manzanita and oak occur over a wide range.

Three roughly parallel vegetation areas, called "life zones", occur from the Sacramento Valley to the Sierran crest. From west to east, these zones are the Great Valley Riparian Forest, Upper Sonoran life zone, Transition life zone, and Canadian life zone (DWR, 1988). These are repeated on the eastern slope of the Sierras. The life zone classification is a generalized vegetation guide. Overlapping of species is common, depending on local conditions of elevation, moisture, and soil. For example, variation exists between vegetation on west-, north-, south-, and east-facing slopes because of the differences in topography, soils and moisture. Plant communities are often affected by past or present land use, particularly when certain species predominate in areas that have been burned or disturbed.

The lower Feather River between Verona and Oroville is in the Great Valley Riparian Forest environmental setting. The predominant forest type on the high floodplain is the Great Valley Oak Riparian Forest, surviving in small patches between agricultural developments. The dominant tree species is the valley oak. Great Valley Mixed and Great Valley Cottonwood riparian forests occur on lower, more recent river meander deposits. Dominant tree species include Freemont cottonwood, sycamore, box elder, and black walnut. Point bar deposits and lower stream banks are the home of the Great Valley Riparian Scrub community, dominated by the narrowleaf willow series.

The Upper Sonoran life zone begins in the foothills above the valley floor. The Upper Sonoran life zone is also called foothill woodland. The primary component of this community is the blue oak, with buckeye, blackjack pine, valley oak and interior live oak also characteristic of this zone. This plant community dominates the western foothills and ridges between approximate elevations of 300 and 1,200 feet.

The Transition life zone is a broad transitional area between the foothill communities and the mixed conifers of the higher elevations. It dominates the elevations between 1,200 and 5,500 feet and contains a large variety of characteristic trees and shrubs. These include big leaf maple, canyon oak, black oak, interior live oak, madrone, ponderosa pine, sugar pine, white fir, Douglas fir, incense cedar, snow brush, deer brush, buck brush, manzanita, and poison oak.

The Canadian life zone occupies higher elevations, generally above 5,500 feet. This plant community is dominated by red fir and lodgepole pine but contains several other characteristic trees and shrubs including white fir, western white pine, sugar pine, western hemlock, plants such as ceonothus, manzanita, chamise, oak species, and blackjack pine grow at elevations below 2,000 feet. Mixed conifer forests containing Jeffrey pine, ponderosa pine, Douglas fir, incense cedar, white fir, red fir, and sugar pine grow at higher elevations. Elevation provides a general control of vegetation type but some plants such as manzanita and oak occur over a wide range.

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The Canadian life zone occupies higher elevations, generally above 5,500 feet. This plant community is dominated by red fir and lodgepole pine but contains several other characteristic trees and shrubs including white fir, western white pine, sugar pine, western hemlock, greenleaf manzanita, bush chinquapin, coyote brush, bitter cherry, and snow brush.

Other plant communities exist in the watershed, which are more a function of soil and moisture than of elevation, including montane meadow, riparian zone, and sagebrush steppe.

Meadows exist in the alluvial valleys along major and minor tributary streams. These relatively flat meadow areas are floodplains, or "stringer" meadows, which are narrow strips along riparian areas, near seeps or springs. Meadows provide food and cover for wildlife and pasture for livestock. Characteristic vegetation is dense growth of sedges and other perennial herbs. Vegetative composition varies depending on the amount of moisture available. Soils are characterized by sandy loam and loamy sand, with a weak, fine granular structure. Without plant roots to hold them together, these soils are easily eroded (USFS, 1989).

The riparian zone includes aquatic ecosystems and distinctive vegetative communities that require a shallow ground water table. Periodic flooding and a generally higher level of moisture promote growth of plants not found elsewhere in the forest. Representative vegetation includes cottonwood, alder, aspen, and willow. Riparian zones are important for wildlife habitat, erosion control, flood control, ground water recharge, and water quality maintenance. The riparian zone extends down from the upper watershed and continues downstream from Lake Oroville to the mouth of the Feather. The riparian zone has been constricted over time by farming and land clearing, resulting in a narrow zone that generally only includes the streambanks and the areas between the levees.

The sagebrush steppe community is dominated by various sagebrush and perennial bunchgrass species. Bunchgrass dominance varies with soil depth and distribution. This community is found mainly in the eastern watershed area below the elevations of coniferous forests or at higher elevations where soils limit forest growth. This community has been substantially degraded by grazing in the past 100 years.

5.1.2.5 Geology

The Feather River watershed includes portions of the Cascade Range, Great Valley, and Sierra Nevada geomorphic provinces. Each province has unique geology and topography, reflecting fundamental differences in geologic history. Primary rock types in the watershed are granitic, volcanic, metamorphic, and sedimentary. Rock ages range from Ordovician to Recent, with most being middle and late Mesozoic. The chief structural feature is the Foothills fault system, consisting of parallel faults oriented roughly southeast-northwest.

5.1.2.5.1 Geologic Units

The Cascade Range province consists of volcanic rocks extending from Lake Almanor to British Columbia. The Cascade Range province comprises 495 square miles (15 percent) of the study area, from Lake Almanor to Lassen Peak. Cascade Range province rocks include tuff, breccia, volcanic ash, lava flows, and lahars of basaltic to rhyolitic composition, ranging in age from Pliocene to Recent.

The Sierra Nevada province abuts the Cascade Range province at Lake Almanor, extending southward about 400 miles to the Mojave Desert. This province occupies 2,810 square miles (85 percent) of the watershed. The Sierra Nevada province includes granitic intrusions, andesitic flows and breccia, basalt, metamorphic rocks, ultramafic rocks, and unconsolidated sedimentary deposits. Cascade Range rocks also occur as the erosional remnants of a thick blanket of volcanic rocks that formerly covered much of the watershed. Uplift of the Sierra Nevada province, by various mechanisms starting in the early Cenozoic, continues today. The current uplift mechanism, which stems from mantle-thinning, commenced approximately five million years ago in the Pliocene epoch (Unruh 1991).

Ultramafic Mesozoic rocks consist largely of serpentinite but also include peridotite, pyroxenite and talc schist. Serpentinite is a moderately soft, green alteration product of ultramafic igneous rock prominent in the central portion of the watershed. It is generally associated with fault zones. An almost continuous band about 3 miles wide crosses the watershed from northwest to southeast. These rocks are structurally weak and landslide-prone.

Jurassic and Cretaceous granitic rocks were emplaced by stoping and shouldering aside overlying rock, forming roughly circular patterns, ranging from less than five miles to over twenty miles in diameter. In the western portion of the watershed, they are bounded by metamorphic rock; in the eastern portion they are partially covered by volcanic flows. Granitic rocks include granite, granodiorite, diorite, and gabbro. Highly weathered or decomposed granite is erodible and prone to landslides and occurs in the eastern watershed and along portions of the North Fork Feather River.

Metamorphic rocks ranging in age from Ordovician to Cretaceous underlie a significant portion of the watershed. These are generally greenschist facies metamorphic rocks occurring along northwest trending belts or in contact areole surrounding intruding plutons. Argillite, slate, mica schist, greywacke, quartzite, and marble were derived from sedimentary rocks. Greenstone, amphibolite, talc schist, and chlorite schist were derived from igneous rocks, or sedimentary rocks derived from igneous rocks. These thin-bedded, foliated and steeply dipping rocks are extensively folded and faulted. Some of these rocks belong to the Smartville Ophiolite Complex. Some of these rocks are often structurally weak and subject to landslides.

Sedimentary deposits include Tertiary gold-bearing or "auriferous" gravels, glacial till, Quaternary alluvium, and landslide deposits. Tertiary auriferous gravels are stream deposits buried by volcanic activity such as flows and lahars during the Eocene and later. The auriferous gravels range from sand-size to boulder-size and contain placer gold. Where exposed by hydraulic mining, these deposits are erodible and landslide prone.

Glacial till forms small moraines at the base of glacial cirques such as those on the slopes of Mt. Lassen. Glacial till deposits are also found in the southern portion of the watershed.

Quaternary alluvium occurs along active stream channels, on floodplains and on valley floors. Most of the deposits occur in the broad, fault bounded valleys in the eastern portion of the watershed. The loose, unconsolidated sand, silt and gravel deposits can be highly erodible where it is exposed on steep slopes in gullies, headcuts, and streambanks.

Landslides occur in a variety of rock types. Large landslides are common around Lake Oroville and along the North Fork Feather River, mostly in metamorphic rocks. Landslides also occur along the Middle Fork Feather. The combination of steep topography and steeply dipping, highly faulted, thin-bedded and weakly metamorphosed sediments in a seismically active area indicates a potential landslide risk. This potential risk ranges from minor rockfalls to destructive landslides. Evidence indicates a historic landslide temporarily blocked the North Fork of the Feather River (DWR, 1979). Landslides in the vicinity of Lake Oroville are discussed in more detail further in the report.

Deposits in the Sacramento Valley proper are only a small fraction of the overall watershed area. It mostly includes a narrow strip along the Feather River between Oroville and Verona. The deposits are older Tertiary sedimentary deposits, Quaternary terrace deposits, basin deposits, and more recent stream-derived channel and floodplain deposits (Figures __).

5.1.2.5.2 Geologic Structure and Seismicity

Geologic structure in the North Fork and Middle Fork Feather River watershed contributes significantly to slope instability and erosion (DWR, 1979). Historic seismicity within and adjoining the watershed is fairly low. Structures include faults, folds, bedding, and foliation.

Two fault types offset rocks in the watershed: High-angle reverse faults in the Sierra Nevada province and normal faults in the Sierra Nevada and Cascade province.

The dominant structure of the Sierra Nevada metamorphic belt is a series of north to northwest-trending, east-dipping reverse faults, called the foothills fault system. These faults were formed during accretion of oceanic, crustal, and island-arc rocks during the late Jurassic Nevadan orogeny (Schweickert and Cowan 1975). Seismicity on these faults has been reactivated in the late Cenozoic (Wong, 1992). Historic seismicity in the foothills fault system include a magnitude 5.7 on August 1, 1975, southeast of Oroville; a magnitude 4.6 on May 24, 1966, near Chico; and a magnitude 5.7 on February 8, 1940, 20 miles east of Chico. Faults also occur in the Sierran Basement below the valley floor. The two most seismically active of these are the Willows fault in the center of the valley and the Great Valley fault along the valley's western edge.

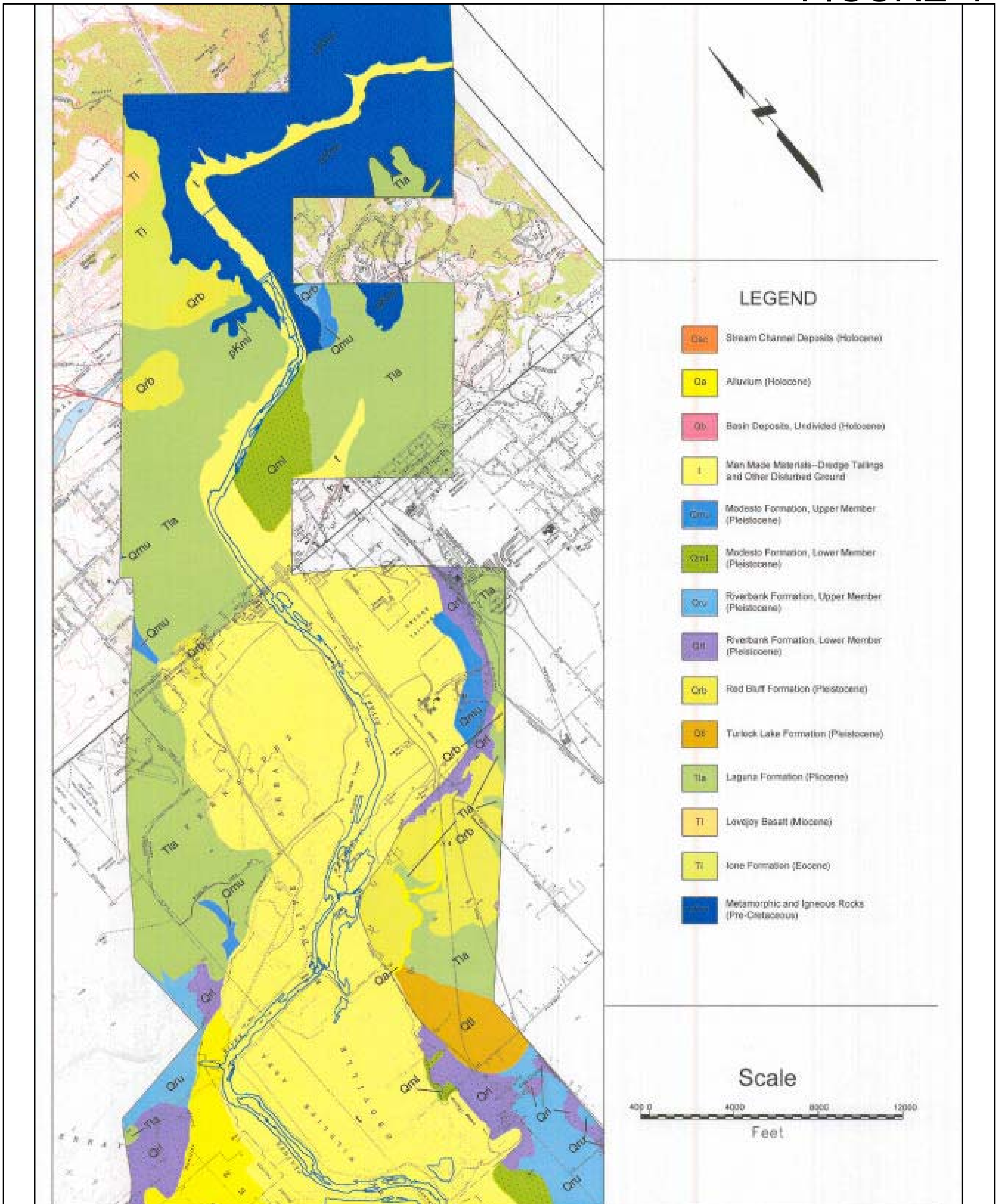
In the eastern portion of the watershed, the dominant structural feature is a series of roughly parallel normal faults, resulting from extensional tectonic forces. This structural regime is related to the adjacent Basin and Range province, which adjoins the Honey Lake Escarpment on the east. Displacement along these faults has created a series of down-dropped broad alluvial valleys bounded by ridges.

Normal faulting is responsible for current seismicity in the eastern watershed area. The greatest magnitude historic seismic event in this area occurred on an unnamed fault near Portola at a magnitude 5.6 in 1959 (DWR, 1993).

Folding is chiefly limited to metamorphic rocks within the Sierra Nevada province with predominant isoclinal folds and overturned relict beds. In general, metamorphic rocks "... dip steeply eastward and form a stack of west-directed thrust sheets." (Hacker, 1993). Folding originated during a succession of deformational events including the late Jurassic Nevadan orogeny in which island arc and arc-trench deposits were accreted to the ancestral north American continent (Schweickert and Cowan, 1975).

Foliation occurs over large portions of the metamorphic rock terrain in the Sierra Nevada province. Foliation is the planar orientation of platy minerals, formed by heating and tectonic compression of rocks. Foliation in these rocks appears as slaty cleavage, oriented southeast-northwest, roughly parallel to the Sierra Nevada crest. Foliation is most pronounced in metamorphosed rocks of sedimentary origin whereas foliation is less common in rocks of volcanic or plutonic origin.

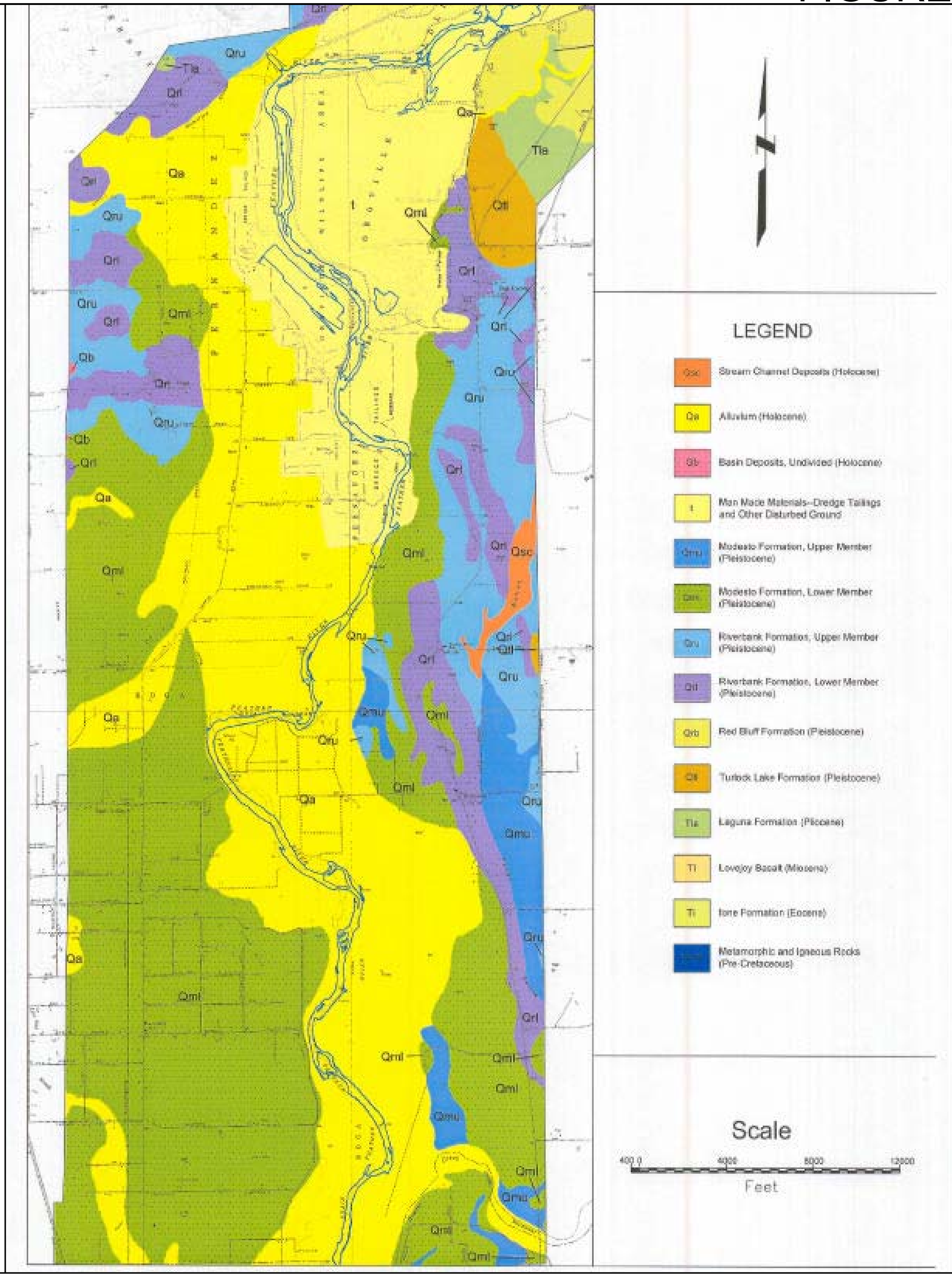
FIGURE 7



OROVILLE FACILITIES RELICENCING

FISH BARRIER DAM TO THERMALITO AFTERBAY LOW FLOW REACH

FIGURE 8



OROVILLE FACILITIES RELICENCING

THERMALITO AFTERBAY TO HONCUT CREEK HIGH FLOW REACH

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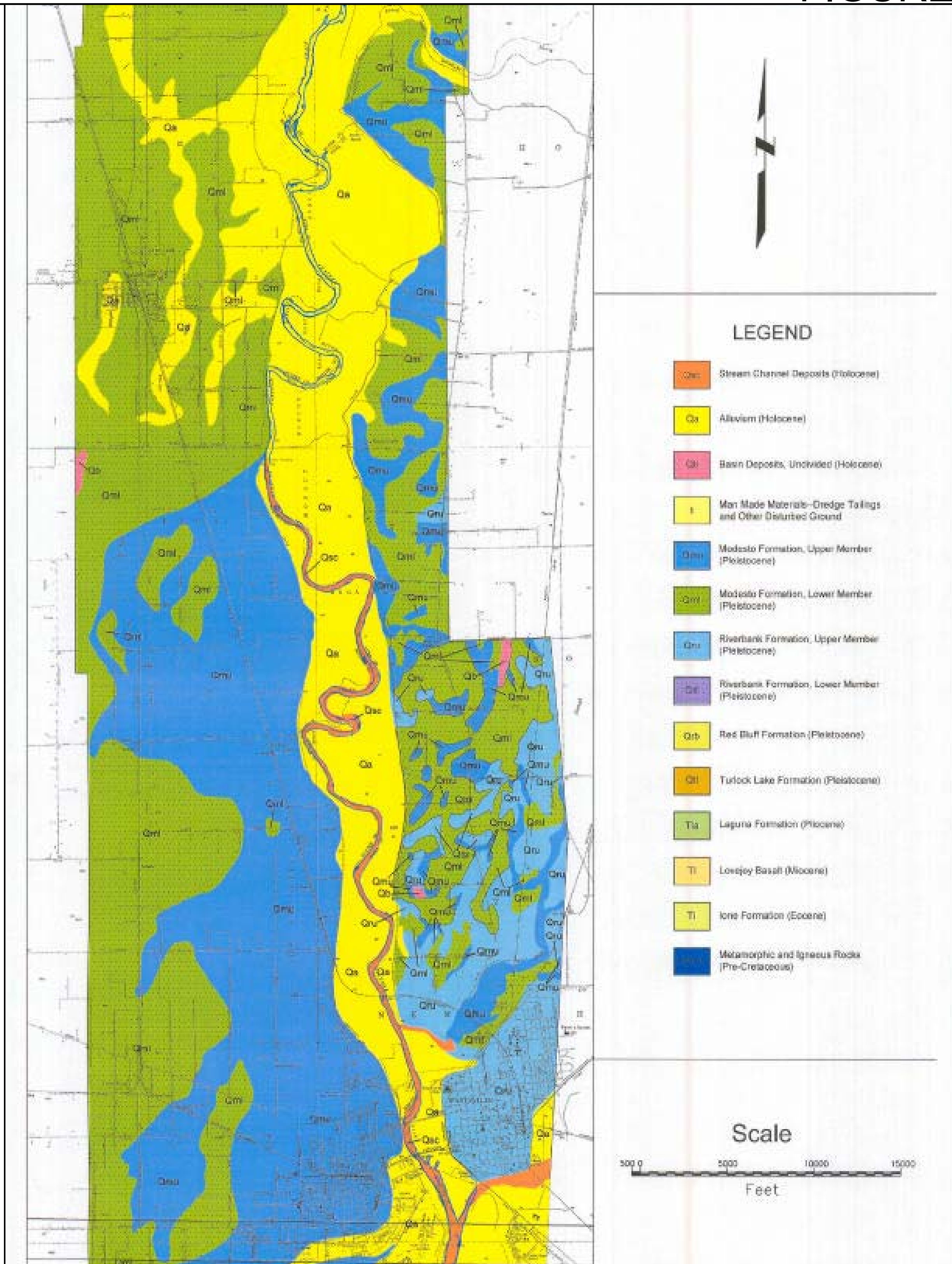
Oroville FERC Relicensing
(Project No. 2100)

FIGURE 9



OROVILLE FACILITIES RELICENSING

HONCUT CREEK TO YUBA CITY

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5.1.2.6 Soils

(In Progress)

5.1.2.7 Hydrology

Natural watershed systems exist in dynamic equilibrium. All the components of a fluvial system such as flow, gradient, channel length, width, and depth, channel bedforms, and floodplains evolve together. These components control the erosion rate, sediment transport, and depositional patterns. Equilibrium may be upset by various land use practices such as cattle grazing, road construction and timber harvesting, or channel modifications such as dams and diversions. Small changes in one place along a stream may have larger effects elsewhere as the hydrologic forces attempt to return to an equilibrium state.

Prior to land and water uses that began in the 1850s, runoff flowed unchecked across mountain meadows and down canyon channels onto the floor of the Sacramento Valley. High flows from winter rain and spring snowmelt sharply contrasted with the low base flows of summer and fall. In the upper watershed where gradients are comparatively gentle, mountain meadows were heavily vegetated and streams followed a meandering pattern. Meadows became floodplains and temporary storage reservoirs, reducing peak flows downstream and reducing the stream's capacity to transport large amounts of sediment. This promoted sediment deposition, groundwater infiltration, and meadow productivity.

The broad alluvial valleys, bounded by volcanic ridges in the eastern topographic area, are considerably altered from their pristine condition. In 1934, John E. Hughes, Junior Forester, Plumas National Forest, described the condition of natural meadow-stream systems (SCS, 1991). "Originally the meadows were well watered by meandering streams whose courses were often concealed by thick vegetation. The streams ran through numerous deep pools covered by lily pads; and in the spring, water stood over practically the entire area of many of the meadows, while the water table was high, even in summer, because the drainage channels were shallow."

After 140 years of water resource development and intensive land use in the watershed, the natural hydrology has been substantially altered. This is evident in the accelerated erosion rates, stream bank degradation, loss of riparian vegetation, head-cutting and gully formation, de-watered aquifers, and sedimentation in downstream reservoirs. This is particularly apparent and well documented in the eastern portion of the North Fork Feather River watershed (DWR, 1990; USFS, 1988; USFS, 1991; USFS, 1992; SCS, 1989; SCS, 1991; PGE, 1986). Reservoirs such as Lake Almanor and Lake Oroville, in turn, have reduced flood flows downstream and in the valley below.

Streams downstream of reservoirs are also affected. Hydraulic alteration, primarily caused by the attenuation of peak flows, increased summer flows, and diversions, affect stream processes such as sediment transport, riffle-pool-run ratios, riparian vegetation, bar development, bank erosion, and others. Sediment is trapped in reservoirs, resulting in sediment starvation in the streams below the dam.

5.1.2.7.1 Water Resources Development

There are numerous reservoirs in the watershed. Most are owned and operated by PG&E and the Department of Water Resources. Table ____ shows the dams of jurisdictional size.

Table 6. Jurisdictional Dams in the Feather River Watershed

Name of Dam or Reservoir	Name of Stream	Drainage Area (Sq. Mi.)	Reservoir Area (Acres)	Storage Capacity (Ac-Ft)	Crest Elevation (Ft)	Year Completed
Antelope	Indian Creek (EBNFFR)	71	890	21,600	5,025	1964
Bidwell Lake (Round Valley Reservoir)	North Canyon Creek (EBNFFR)	9.12	400	4,800	4,495.6	1865
Bucks Diversion	Bucks (NFFR)	30.6	136	5,843	5,039.5	1928
Bucks Storage (Bucks Lake)	Bucks Creek (NFFR)	28	1,827	103,000	5,178.5	1928
Butt Valley	Butt Creek (NFFR)	75	1,600	53,120	4,144	1924
Caribou Afterbay	North Fork Feather River	616	42	3,400	2,985	1959
Chester Diversion	North Fork Feather River	113	15	75	4,610	1975
Cresta	North Fork Feather River	1,872	62	4,400	1,680	1949
Eureka Lake	Eureka Creek (MFFR)	0.64	42	400	6,200	1866
Feather R. Hatchery	Feather River	3,640	52	580	181	1964
Frenchman	Little Last Chance Creek (MFFR)	82	1,470	51,000	5,607	1961
Grizzly Creek	Grizzly Creek (NFFR)	50.5	11	140	5,054	Unknown
Grizzly Forebay	Grizzly Creek (NFFR)	12.6	38	1,112	4,337.8	1928